The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., APRIL, 1921. No. 4

Boiler Operation at the Power Plant of The Mesta Machine Company

Description of How Close Observation Led to the Installation of Mechanical Devices and Instruments, and the Economy That Resulted.

By C. FISCHER,
Supt. of Power, Light and Heat, Mesta Machine Company.

THE vast amount of fuel used daily, especially coal, in the generation of steam, has brought before the public in general and the plant owner and operating engineer in particular the necessity of finding and adopting such means and methods as will help to increase the overall boiler efficiency and to reduce the fuel losses.

It is therefore essential that the operator be acquainted with the basic principles entering into the efficient use of the particular fuel, and that such instruments and apparatus are put at his disposal as will enable him not only to check his operation at any time, but also to have full control of the varying conditions, such as are met with during operation, and to keep permanent records.

Since the boiler as in general use at present is accepted as a highly developed and efficient heat absorbing apparatus, particular attention has to be paid to the heat production in the furnace, as by far the greatest part of the losses occur during the process of producing and guiding the heat.

The production of heat is a chemical process, called combustion. During this process the combustible elements or compounds of the fuel combine with the oxygen. This combustion however can only take place at the proper temperature, called the ignition temperature of the combustible. It is consequently necessary for the proper amount of oxygen to be present at the ignition temperature of the combustible matter, before combustion can take place. The ignition temperature of the various combustible substances varies.

The oxygen necessary for combustion is taken from the air, which is a mechanical mixture of oxygen, nitrogen and small amounts of other gases. The generally accepted amounts existing in the air are:

	Volume per cent	Weight per cent
O_2 Oxygen	21.00	23.15
N_2 Nitrogen	79.00	76.85

For every pound of oxygen required for combustion 3.32 lbs. of nitrogen or 4.32 lbs. of air have to be introduced into the furnace. Nitrogen has no useful purpose during the process of producing heat, but is an element which absorbs heat, thus entailing a direct loss. The success of burning the fuel efficiently therefore, depends largely on the proper amount of air supplied. How important a part the air supply plays in the heat producing process will be more fully discussed later.

As the boiler plant, of which the operation is to be analyzed later, is a coal fired installation, the fuel to be considered will be bituminous coal from the Pittsburgh district.

The combustible element most prominent in coal is carbon, of which the atomic symbol is C. When one carbon atom C combines at the proper temperature with two atoms of oxygen of the atomic symbol O it is said that combustion is complete. The product of combustion is called carbon dioxide having the molecular symbol CO_2.

$$C + 2O = CO_2$$

The atomic or combining weight of carbon is 12 and that of oxygen is 16, therefore

$$12 + (2 \times 16) = 44$$

12 lbs. of carbon plus 32 lbs. of oxygen form 44 lbs. of carbon dioxide.

One pound of carbon therefore requires 2.667 pounds of oxygen for complete combustion, and the weight of the product of combustion must be $1 + 2.667 = 3.667$ pounds of carbon dioxide. One pound of carbon dioxide consequently consists of:

$$\frac{12}{44} = 0.2727 \text{ pounds of carbon and}$$

$$\frac{32}{44} = 0.7273 \text{ pounds of oxygen or any weight of}$$

CO_2 is composed of 27.27 per cent C and 72.73 per cent O_2.

Since one pound of oxygen is contained in 4.32 pounds of air, the amount of air required for the complete combustion of one pound of carbon is:

$$2.667 \times 4.32 = 11.52 \text{ pounds.}$$

and since every pound of air contains 0.7685 pounds of nitrogen, the total amount of nitrogen is:

$$0.7685 \times 11.52 = 8.853 \text{ pounds.}$$

The total weight of flue gases for the perfect combustion of one pound of carbon amounts to:

$$\begin{array}{ll} 3.667 \text{ lbs.} & CO_2 \\ 8.853 \text{ lbs.} & N_2 \\ \hline 12.520 \text{ lbs.} & \end{array}$$

The above represents the process, expressed in weights, for perfect combustion of carbon, that is to say, each carbon atom has been supplied with two atoms of oxygen by supplying just the proper weight of air, no more nor less. If more air had been supplied than was necessary to satisfy each carbon atom for its affinity for oxygen, the total weight of the flue gases would have been increased by that amount of excess air, and this amount of excess air would have absorbed some of the heat produced in addition to that absorbed by the 8.853 pounds of nitrogen, which had to accompany the 2.667 pounds of oxygen necessary for the complete combustion of one pound of carbon. Although combustion can be complete with an excess amount of air, it can no longer be perfect, owing to the presence of the excess air.

During the process described above, heat is produced and the amount of heat produced in burning one pound of carbon complete is 14,600 Btu. This represents the quantity of heat, the unit of which is that amount necessary to raise the temperature (quality of heat) of one pound of water 1 degree F. The more correct and now generally accepted definition of the Btu is the $\frac{1}{180}$ amount of heat required to raise the temperature of one pound of water from 32 to 212 degrees F. at atmospheric pressure.

If the air supplied during the process of combustion is insufficient to satisfy the affinity of carbon for oxygen, combustion is no longer complete, and instead of forming carbon dioxide CO_2 carbon monoxide having the molecular symbol CO is the result.

$$C + O = CO$$
$$12 + 16 = 28$$

The amount of oxygen involved during this combination is 1.333 pounds per pound of carbon and the resulting weight of the product of combustion is 2.333 pounds of CO. The weight of air is therefore

$$1.333 \times 4.32 = 5.76 \text{ pounds}$$

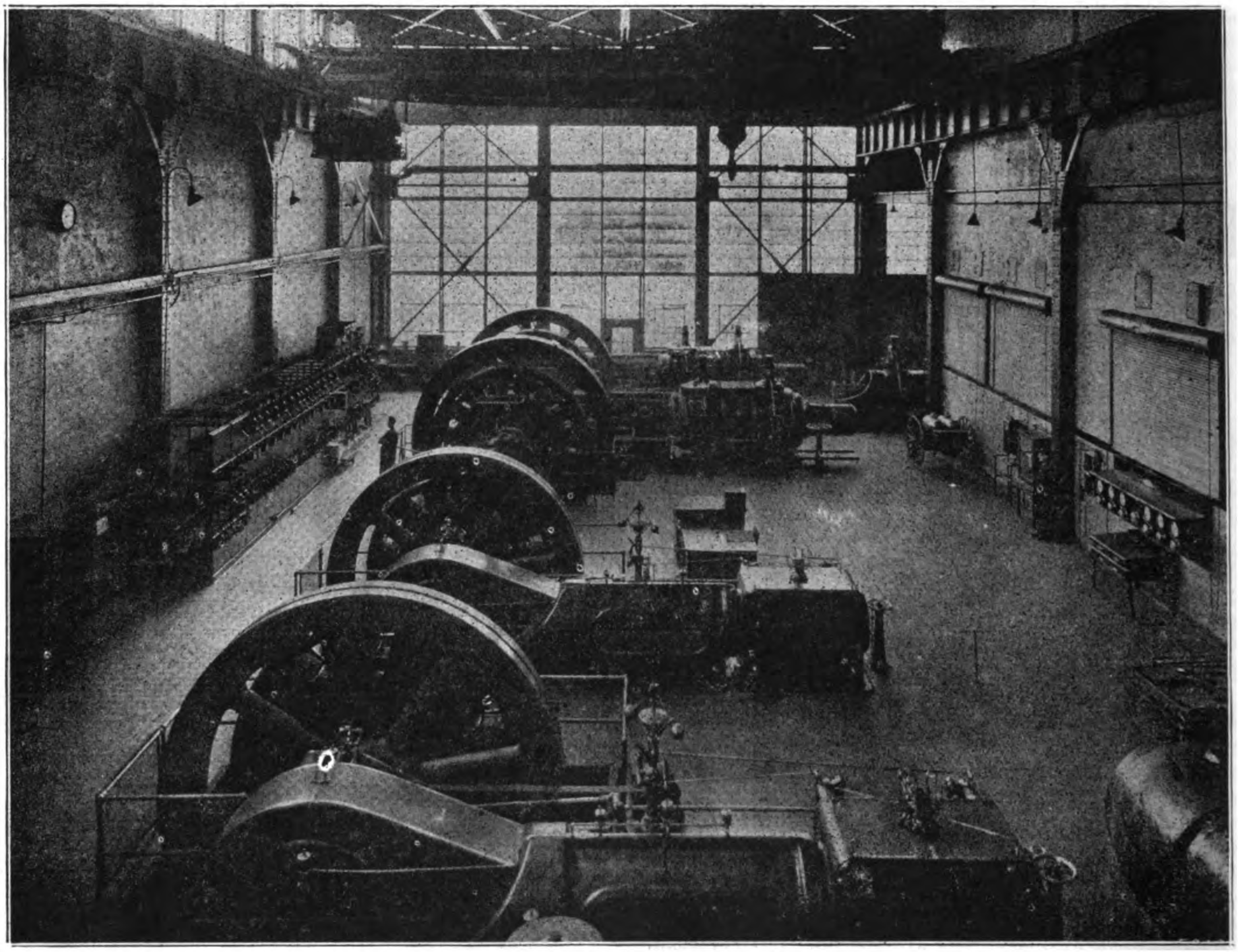

Fig. 1—View of Power House looking toward Mesta Unaflow Engines. Westinghouse switchboard to the left of photograph.

and nitrogen

$$5.76 \times 0.7685 = 4.427 \text{ pounds.}$$

The weight of flue gases for incomplete combustion of 1 pound of carbon is therefore composed of:

2.333 lbs. CO
4.427 lbs. N_2
6.76 lbs.

The heat evolved during the process of incomplete combustion is 4450 Btu.

Should the CO so formed, pick up during its passage through the furnace another atom of oxygen, combustion can be completed, provided the temperature is right. If therefore the 2.333 pounds of carbon monoxide are supplied with the necessary oxygen amounting to 1.333 pounds, 3.667 pounds of CO_2 are formed, and the heat produced must be 14,600 — 4450 = 10,150 Btu. The heat produced in oxidizing 1 pound of CO forming CO_2, consequently amounts to $\frac{10,150}{2.333} = 4359$ Btu.

The amount of oxygen required during this combination is $\frac{16}{28} = 0.57$ pounds, the weight of CO_2 equals 1.57 pounds. The weight of air necessary to supply the oxygen is 2.47 pounds and the weight of the accompanying nitrogen is 1.90 pounds.

The second element in coal to be considered is hydrogen. Hydrogen has to be completely oxidized or not at all, therefore, if the air supply is not sufficient, part of the hydrogen will oxidize and the rest will leave the flues unburned. The atomic symbol of hydrogen is H and the atomic weight is one, while the molecular symbol is H_2 and the molecular weight is 2. The product of combustion is H_2O, two atoms of hydrogen combine with one atom of oxygen to form water vapor.

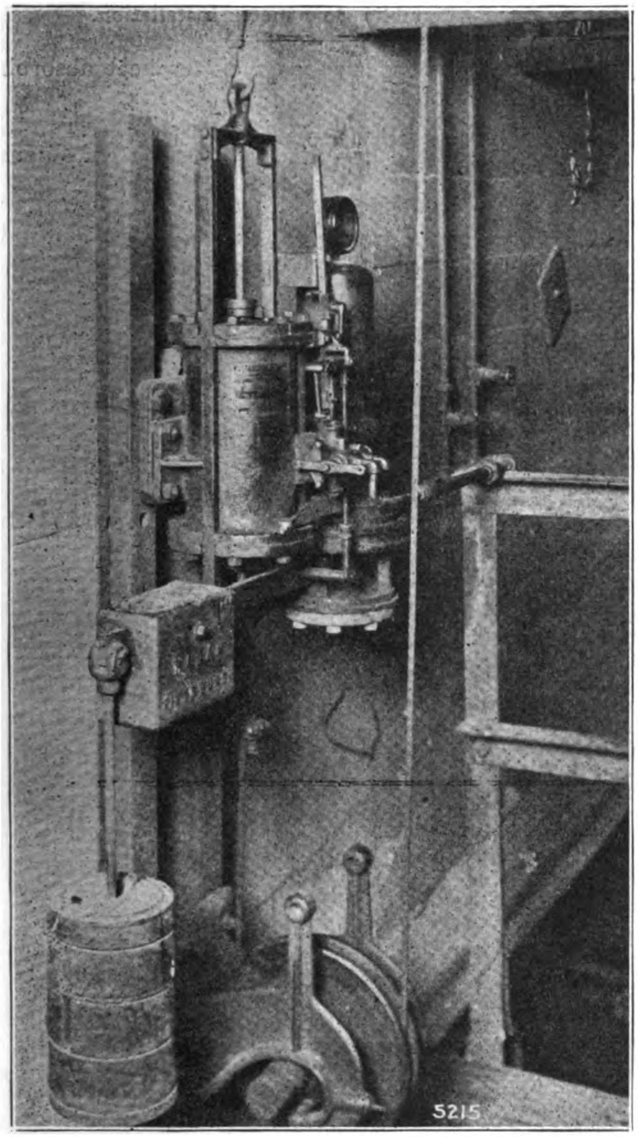

Fig. 2—View of Hagan Regulator.

$$2\,H + O = H_2O.$$

Since the combining weights are 1 and 16 respectively, 2 pounds of hydrogen require 16 pounds of oxygen to form 18 pounds of water vapor

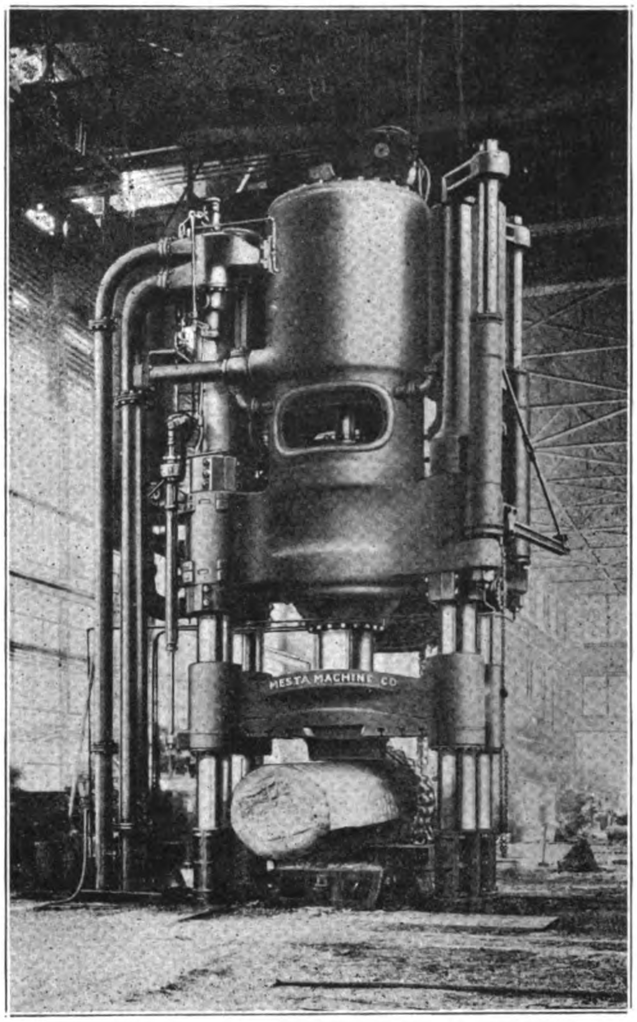

Fig. 3—View of 2,000-ton Mesta press used in forge shop.

$$(2 \times 1) + 16 = 18$$

Consequently 1 pound of hydrogen requires 8 pounds of oxygen, or 8 × 4.32 = 34.56 pounds of air. With this weight of air 34.56 — 8 = 26.56 pounds of nitrogen have to be supplied. The weight of the product of combustion H_2O amounts to 9 pounds and the total weight of the flue gases are:

9.00 lbs. H_2O
26.56 lbs. N_2

35.56 lbs.

The heat produced when oxidizing of 1 pound of hydrogen is 62,000 Btu.

The third element is sulphur, having the atomic symbol S and an atomic weight of 32. The molecular weight is 64 and the molecular symbol S_2. Sulphur can either combine with two or three atoms of oxygen forming sulphur dioxide SO_2 or sulphur trioxide SO_3.

In the former case

$$S + 2O = SO_2 \text{ or}$$
$$32 + 2\,(16) = 64$$

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and in the latter case

$$S + 3O = SO_3 \text{ or}$$
$$32 + 3\ (16) = 80$$

Consequently the oxygen required to burn 1 pound of sulphur to form SO_2 is 1 pound and the amount of air 4.32 pounds. The nitrogen therefore is 3.32 pounds. The weight of SO_2 formed during the combustion of 1 pound of sulphur is 2 pounds, consequently the flue gases consist of

$$\begin{array}{l} 2.00 \text{ lbs. } SO_2 \\ 3.32 \text{ lbs. } N_2 \\ \hline 5.32 \text{ lbs.} \end{array}$$

For the formation of SO_3, from 1 pound of sulphur 1.5 pounds of oxygen or 6.48 pounds of air are required, leaving 2.5 pounds of SO_3 and 4.98 pounds of N_2, or a total weight of flue gases equal 7.48 pounds.

The heat produced in burning 1 pound of sulphur to SO_2 is about 4050 Btu and to SO_3 about 5950 Btu. The heat value of sulphur is comparatively low and the quantities contained in the average coal are very small, so that sulphur really does not play an important part as a heat producing element in coal fired boilers. It might however be worth mentioning, that SO_2 and SO_3 readily combine with H_2O, forming H_2SO_3 and H_2SO_4. These products are sulphurous and sulphuric acids which, if occurring in any appreciable quantities, will do damage to any iron with which they may come into contact.

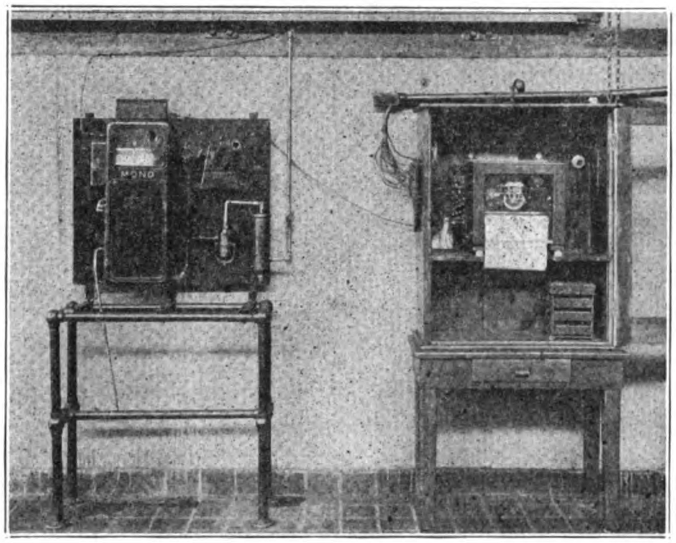


Fig. 4—Mono instruments for the gas analysis and Leeds & Northrup pyrometer for flue gas temperatures and steam temperatures.

Besides the combustible elements mentioned, there appears in coal usually a small percentage of oxygen and nitrogen. The nitrogen is useless, but has to be considered as a heat absorbing element, and therefore has to be added to the amount contained in the air, which is admitted into the furnace for combustion. With the oxygen just the reverse takes place, the amount already contained in the coal can be subtracted from that necessary for combustion.

During the practical boiler operation a certain percentage of excess air has to be admitted to insure a good mixture of oxygen with the combustibles, and to obtain complete combustion. It is the amount of excess air which gives the operator a means to judge the efficiency of combustion. For every per cent excess air which is admitted a certain amount of heat is lost, since the air has to be brought up to the furnace temperature, thus absorbing heat and carrying it away up the chimney; as a matter of fact excess air up to certain amounts increases the flue gas temperature rather than decreasing it, for the reason that air has a better heat absorbing quality than the boiler.

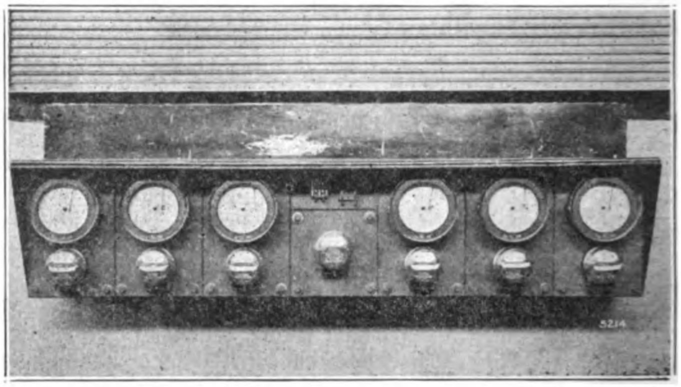


Fig. 5—Republic flow meter installation.

For every per cent of excess air admitted to the boiler furnace for the complete combustion of 1 pound of carbon

$$\frac{11.52 \times 1.0 \times 0.2315}{100} = 0.0267 \text{ pounds of } O_2$$

and

$$\frac{11.52 \times 1.0 \times 0.7685}{100} = 0.08853 \text{ pounds of } N_2$$

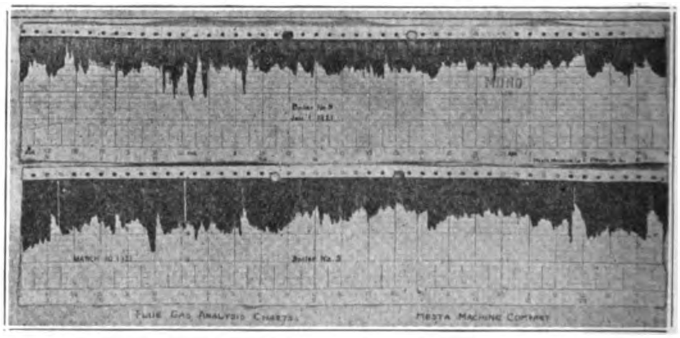
have to be supplied.

The total weight of flue gases for the complete combustion of 1 pound of carbon without excess air is 12.52 pounds. Assuming that the temperature of air entering the furnace is 65 degrees F., and that the flue gases leave the boiler at a temperature of 565 degrees F., and that the specific heat of the flue gases is 0.24, then the total amount of heat carried away by the flue gases is:

$$12.52 \times (565 - 65) \times 0.24 = 1502.4 \text{ Btu}$$

and since the heat value of carbon is 14,600 Btu

$$\frac{1502.4 \times 100}{14{,}600} = 12.29 \text{ per cent of the heat is lost.}$$



If now 50 per cent excess air is admitted the products of combustion are:

	Pounds
CO_2	= 3.667
$O_2 = 0.0267 \times 50$	= 1.335
$N = 8.853 + (50 \times 0.08853)$	= 13.278
	18.280

The heat lost now amounts to:

$$18.28 \times (565 - 65) \times 0.24 = 2194 \text{ Btu or}$$
$$\frac{2194 \times 100}{14,600} = 15.03 \text{ per cent}$$

Specific heat of flue gases has been mentioned, which means that for every degree F. raise in temperature of 1 pound of these gases 0.24 Btu are absorbed. Not only does the specific heat of the various substances vary, but it also varies with the temperature.

In table 1 are the foregoing combustion data, compiled:

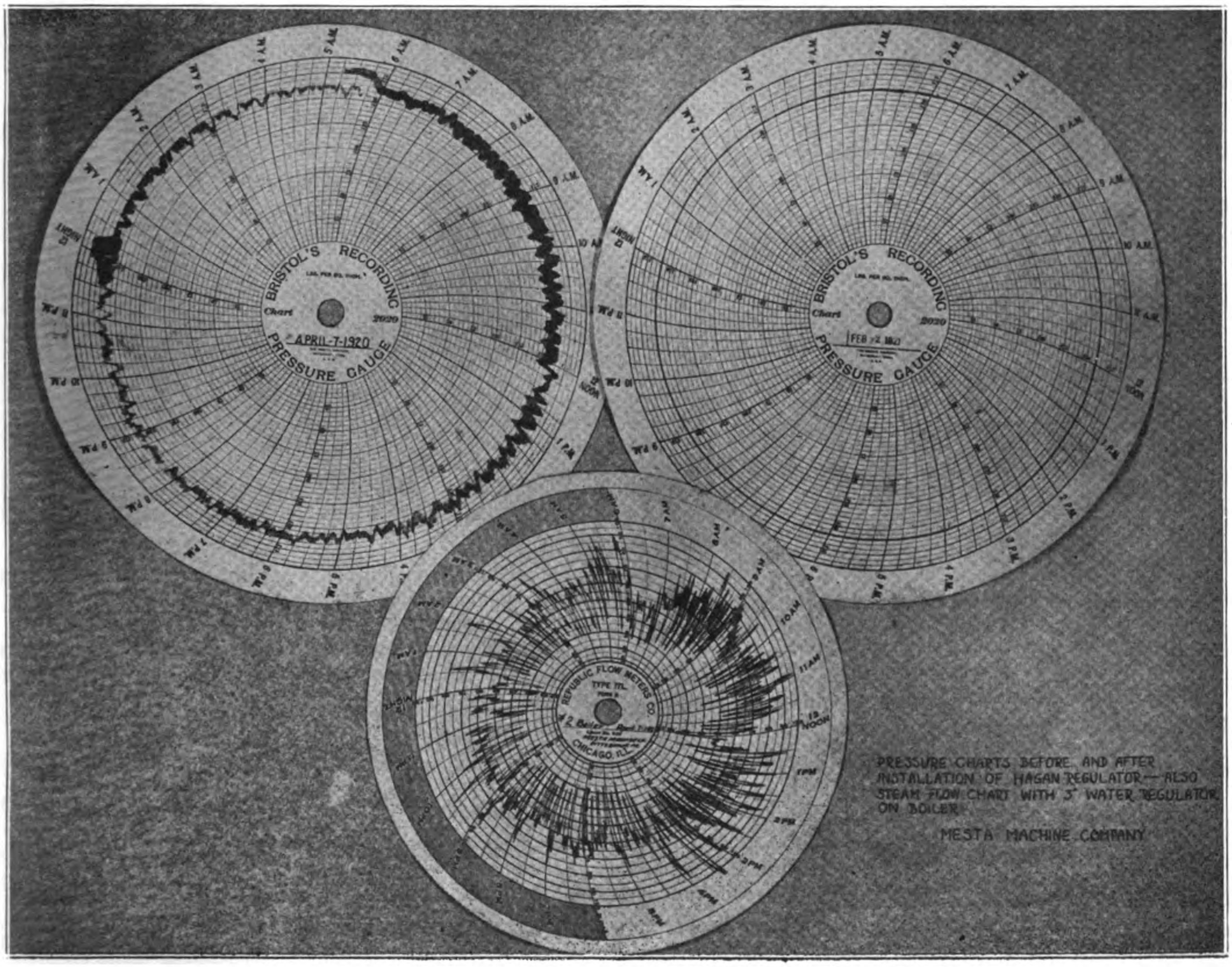
Sample	H_2	C	N_2	O_2	Ash	S	Btu
I	4.13	61.28	1.27	8.04	23.72	1.56	11144
II	4.54	73.42	1.57	5.21	14.08	1.18	12927

Taking two samples of different coals as fired under the boilers of the Mesta Machine Company, the various processes as outlined before can be followed.

Table I.

Tabulated data of the foregoing expressed in pounds per pound of combustible.

Substance	Heat of combustion per lbs. of combustible btu.	Atomic		Molecular		Required pounds		Weight in pounds of products of combination per pound of combustible.						Total weight lbs. of flue gas per lb. of combustible.
		Symbol	Wgt	Symbol	Wgt	Oxygen	Air	CO_2	CO	H_2O	SO_2	SO_3	N_2	
Carbon to CO_2	14,600	C	12	..	..	2.667	11.52	3.667	....	....	....	....	8.853	12.52
Carbon to CO	4,450	C	12	..	..	1.333	5.67	....	2.333	....	....	....	4.427	6.67
Carbon Monoxide	4,350		..	CO	28	0.570	2.47	1.57	....	....	....	....	1.900	3.47
Hydrogen	62,000	H	1	H_2	2	8.00	34.56	....	....	9.00	....	....	26.56	35.56
Sulphur to SO_2	4,050	S	32	S_2	64	1.00	4.32	....	....	....	2.00	....	3.32	5.32
Sulphur to SO_3	5,950	S	32	S_2	64	1.50	6.48	....	....	....	....	2.50	4.98	7.48
Oxygen	....	O	16	O_2	32	....	....	....	....	....	....	....	....	....
Nitrogen	....	N	14	N_2	28	....	....	....	....	....	....	....	....	....



PRESSURE CHARTS BEFORE AND AFTER INSTALLATION OF HAGAN REGULATOR—ALSO STEAM FLOW CHART WITH 3" WATER REGULATOR ON BOILER

MESTA MACHINE COMPANY

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Products of Combustion—Sample I.

	Pounds
CO_2	= 0.6128 + 1.6343 = 2.2471
H_2O	= 0.0413 + 0.3304 = 0.3717
SO_2	= 0.0156 + 0.0156 = 0.0312
N_2	= 6.3207
	8.9707

SO_2 appears in the ordinary flue gas analysis apparatus (Orsat) as CO_2, so that the products of combustion as shown by the analysis are:

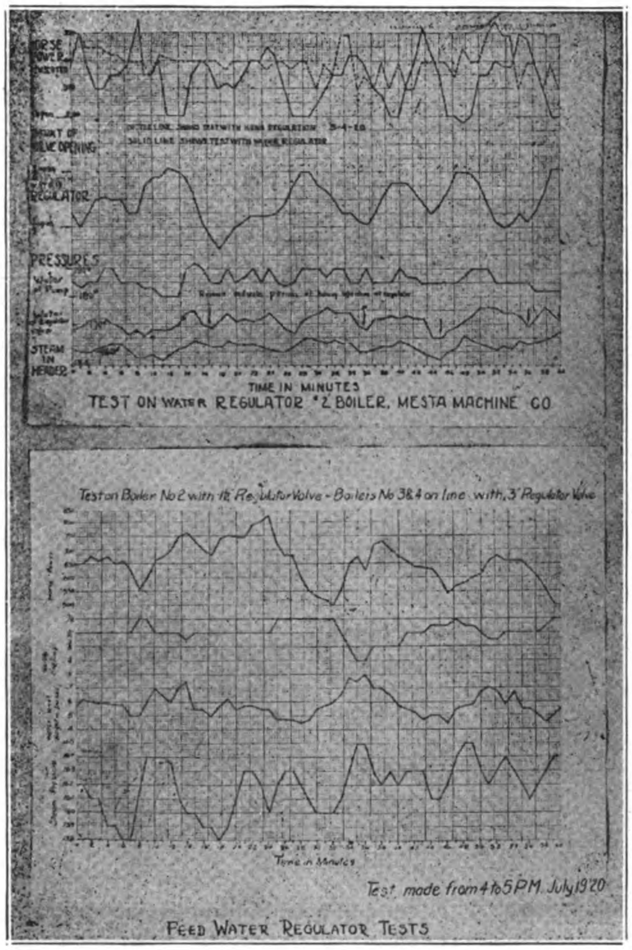
	Pounds
CO_2	= 2.2783
H_2O	= 0.3717
N_2	= 6.3207
	8.9707

Since the total amount of air required for the complete combustion of 1 pound of coal is 8.208 pounds, for 50 per cent excess air, the weight of oxygen and nitrogen amounts to

$$8.208 \times 0.50 \times 0.2315 = 0.9500 \text{ lbs. of } O_2$$
$$8.208 \times 0.50 \times 0.7685 = 3.1540 \text{ lbs. of } N_2$$

The products of combustion with 50 per cent excess air are:

	Pounds
CO_2	= 2.2783
O_2	= 0.9500
H_2O	= 0.3717
N_2	= 9.4747
	13.0747



Converting the actual weights of products of combustion for the complete combustion of 1 pound of coal without excess air and with 50.0 per cent excess air into per cent weight the following is obtained:

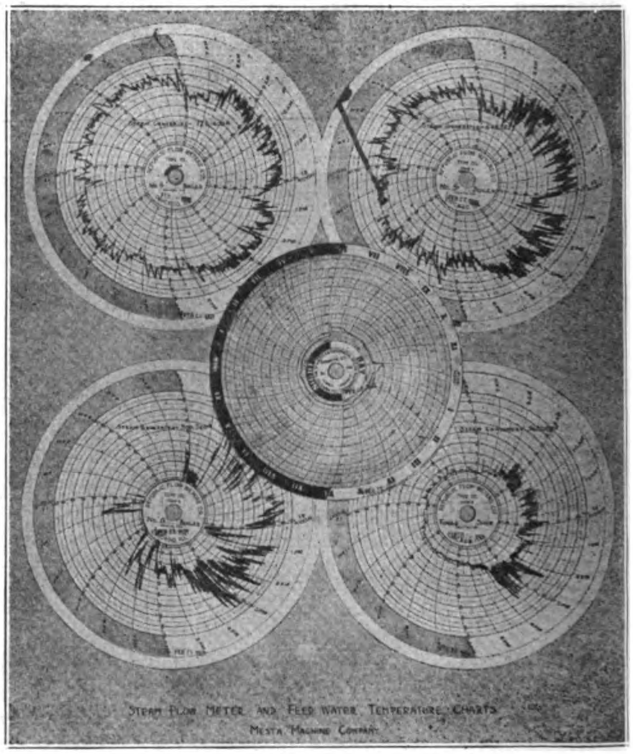
Percent Weight—Sample I.

	0.0% excess air %	50.0% excess air %
CO_2 =	25.398	17.425
O_2 =		2.843
H_2O =	4.143	7.266
N_2 =	70.459	72.466
	100.000	100.000

Since the flue gases analyzed are dry the percentage weight is:

	0.0% excess air %	50.0% excess air %
CO_2 =	26.495	17.936
O_2 =	....	7.478
N_2 =	73.505	74.586
	100.000	100.000

The flue gas analysis apparatus gives the percentages of the various constituents in volumes instead of in weights and the per cents weight have to be converted in per cents volume.



For converting analysis by weight into analysis by volume the molecular weights of the constituents of the gas or the densities can be used. Using the molecular weight:

0.0% Excess Air—Sample I.

	% weight	Molecular weight		% volume
CO_2	26.495	44	$\frac{26.495}{44} = 0.6021$	$\frac{0.6021 \times 100}{3.2271} = 18.65$
O_2	0.000		..	
N_2	73.505	28	$\frac{73.505}{28} = 2.6250$	$\frac{2.6250 \times 100}{3,2271} = 81.35$
	100.00		3.2271	100.00

50.0% Excess Air—Sample I.

	% weight	Molecular weight		% volume
CO_2	= 17.936	$\frac{17.936}{44} = 0.40763$		$\frac{0.40763 \times 100}{3.30419} = 12.336$
O_2	= 7.478	$\frac{7.478}{32} = 0.23370$		$\frac{0.23370 \times 100}{3.30419} = 7.073$
N_2	= 74.586	$\frac{74.586}{28} = 2.66286$		$\frac{2.66286 \times 100}{3.30419} = 80.591$
	100.00	3.30419		100.000

Products of Combustion—Sample II.

		Pounds
CO_2	= 0.7342 + 1.9581	= 2.6923
H_2O	= 0.0454 + 0.3632	= 0.4086
SO_2	= 0.0118 + 0.0118	= 0.0236
N_2		= 7.5887
Total		=10.7131

Products of Combustion as they appear in Flue Gas Analysis.

	Weight lbs.	Weight %
CO_2	= 2.7159	25.3510
H_2O	= 0.4086	3.8140
N_2	= 7.5887	70.8350
	10.7132	100.0000

With an excess air supply of 50 per cent the following has to be added:

$$9.854 \times 0.50 \times 0.2315 = 1.1406 \text{ lbs. of } O_2$$
$$9.854 \times 0.50 \times 0.7685 = 3.7864 \text{ lbs. of } N_2$$

and the weights of the gases are

	Weight lbs.	Weight %
CO_2	= 2.7159	17.3649
O_2	= 1.1406	7.2927
H_2O	= 0.4086	2.6125
N_2	= 11.3751	72.7299
	15.6402	100.0000

It can readily be seen how important a part the air supply takes during the process of combustion, and that the air supply has to be changed to suit different qualities of coal. The proper amount of air has been supplied when the flue gas analysis shows just a trace of CO; this indicates that combustion has been complete and that the proper amount of air for the existing furnace conditions has been supplied.

In most industrial power plants steam is used for various purposes as in the case of the Mesta Machine Company, where steam is used.

1) In Mesta unaflow and Corliss engines to generate electric energy.

2) In Mesta air compressors to supply the compressed air necessary for the manufacture of the products.

3) In Mesta forging presses and steam hammers.

The demand of steam varies within wide limits and the boiler plant and boiler plant equipment has to take care of these variations without loss in economy.

To rely entirely on the human element to obtain the best results would not be good policy. The average fireman usually has no conception of the amount of money involved, his business is to make steam, to watch the steam gauge and keep the pressure up, he has not been brought up to think in Btu's. It is therefore up to the man in charge to do the thinking and operating, and as he cannot rely on the human element he has to adopt such mechanical means as suit the particular plant conditions the best. These mechanical means should enable the operating man to plan ahead rather than base today's operation on the results of yesterday. The conditions of yesterday may have been materially different from what they are today and to draw any conclusions without analyzing these conditions in detail may become a very expensive process.

The boiler plant consists of six Heine Safety Boilers, of the following specification:

Sample I.

Required for complete combustion of one pound of coal.

Products of Combustion	Oxygen pound	Nitrogen pound	Air pounds
CO_2	0.6128 × 2.667 = 1.6343	1.6343 × 3.32 = 5.426	1.6343 × 4.32 = 7.060
H_2O	0.0413 × 8.000 = 0.3304	0.3304 × 3.32 = 1.097	0.3304 × 4.32 = 1.427
SO_2	0.0156 × 1.000 = 0.0156	0.0156 = 3.32 = 0.052	0.0156 × 4.32 = 0.067
Total	1.9803	6.575	8.554
Oxygen in coal	0.0804		
Total oxygen required	1.8999		
Total air required	1.9 × 4.32 =		8.208
Total Nitrogen	(1.9 × 3.32) + 0.0127 = 6.3207		

Sample II.

Required for complete combustion of one pound of coal.

Products of Combustion	Oxygen pound	Nitrogen pound	Air pound
CO_2	0.7342 × 2.667 = 1.9581	1.9581 × 3.32 = 6.501	1.9581 × 4.32 = 8.459
H_2O	0.0454 × 8.000 = 0.3632	0.3632 × 3.32 = 1.206	0.3632 × 4.32 = 1.569
SO_2	0.0118 × 1.000 = 0.0118	0.0118 × 3.32 = 0.039	0.0118 × 4.32 = 0.051
Total	2.3331	7.746	10.079
Ogygen in coal	0.0521		
Total oxygen required	2.2810		
Total air required	2.281 × 4.32 =		9.854
Total Nitrogen	(2.281 × 3.32) + 0.0157 = 7.5887		

Number of boilers 6
Heating surface of one boiler..............5450 square feet
Rated boiler horsepower ....545 hp

Design of Pressure Parts.

Number of steam and water drums........2
Diameter of drums ....42 inches
Length ....22 feet
Thickness of plate..........................13/32 inches
Heads dished, thickness ....½ × ⅝ inches

Manhole in rear of drums 11x15 inches, flanged-in reinforced with pressed steel covers. Longitudinal seams, double strap butt joints double riveted, girth seams lap single riveted. Water legs of flanged steel plate 17/32 inches thick, stayed with hollow staybolts and drop forged throat stay.

Tubes.

Material ....Mild steel
Diameter of tubes ....3½ inches
Length of tubes ....18 feet
Number of tubes 315
Number of rows high......................18
Number of tubes per row.................17 and 18

Working and Test Pressures.

Working pressure ....160 pounds per square inch
Test pressure ....240 pounds per square inch

Superheaters.

Heating surface ....864 square feet

Each boiler is equipped with a Westinghouse underfeed stoker of the 5-retort double dumping grate type. The specification of these stokers is as follows:

General Description.

The stokers are of the inclined underfeed type, having interlocking tuyeres for the distribution of air to fuel and provided with the necessary actuating mechanism for controlling the supply of fuel and for discharging the ash and clinker.

Stoker Equipment.

The equipment consists of the coal hoppers, unit retorts, heavy half fronts and anchor bolts, front and side observation doors, tuyeres and dumping grates.

The stokers are set in combination with six 545 hp Heine boilers, the normal rating of which is based on 10 square feet of effective heating surface per boiler hp.

Stoker Engines.

For driving the stokers, two stoker engines are provided, which can drive the stokers either jointly or separately.

Fan Equipment.

For operating six boilers at 200 per cent load, forced draft totalling 75,000 cu. ft. of air per minute at 65 degrees F. and a static pressure of 6-inch water gauge in the wind box of each stoker is required.

To operate six boilers at 290 per cent rating 134,400 cu. ft. of air per minute at 65 degrees F. are required at a static pressure of 7-inch water gauge in the wind box of each stoker.

The fan equipment consists of two No. 9 extra heavy multivane, design No. 3 Sturtevant Fans, directly coupled by means of flexible couplings to two Westinghouse variable speed motors, which latter are controlled by Westinghouse automatic starters with push button station.

The characteristic of each fan is as follows:

	5-inch pressure water gauge		6-inch pressure water gauge	
Speed	Vol.	Horsepower	Vol.	Horsepower
546	39,000	52	....	..
567	43,000	62	....	..
589	47,000	72	40,100	62
631	54,600	98	48,200	86
672	62,100	125	56,300	115
715	69,700	160	63,900	145

For the control of the boilers each individual boiler is equipped with:

1) Indicating steam pressure gauge.
2) Draft gauge.
3) Republic steam flow meters consisting of
    a) One indicating instrument calibrated in horsepowers, mounted beside steam pressure gauge.
    b) One recording instrument giving the flow of steam per hour.
    c) One integrating instrument giving the flow of steam during any period.

The steam pressure of the main steam header is indicated by a pilot pressure gauge of the illuminated scale type, and one recording Bristol pressure gauge.

Coal and consequently air should be supplied to the boilers in accordance with the steam demand. This necessitates regulating the amount of coal, air and draft for exit gases frequently, if it is not done at the proper time the steam pressure will drop when the steam demand is heavy and the safety valves will blow when that demand period is over. Furthermore the pressure over the fires should be as near atmospheric pressure as possible, in order to prevent infiltration of air on the one hand, and to insure free combustion and to prevent gases blowing out of furnace doors.

After careful study of the existing operating conditions it was decided to instal the Hagan regulator to take care of the wide and sudden variations in the steam demand. The installation of the Hagan regulator proved to be a complete success, as the regulator not only regulates the fuel and air supply as well as draft conditions in accordance with steam demand, but owing to its flexibility and simplicity in operation it is possible to adjust the coal and air supply as well as draft individually or collectively to suit any variations in the quality of coal.

The steam and flue gas temperatures are recorded by a Leeds & Northrup pyrometer.

In order to control the combustion and to take care of any change in the quality of coal, indicating the time when adjustments on the Hagan regulator are necessary a Duplex Mono instrument has been installed. This was done first, to obtain a continuous flue gas record and second, to facilitate the observation of any change in operation.

The Duplex Mono instrument records the CO_2 and CO contents in the flue gases. A simple CO_2 recorder would not have been suitable for Mesta boiler house conditions, owing to the variations in the quality of coal and load. Where the composition of coal remains uniform and the furnace conditions do not change to any great extent a CO_2 recorder will prove beneficial, as a check with the Orsat apparatus at frequent intervals will soon show whether the proper amount of air is being supplied, but in cases where qualities of coal and furnace conditions change as often as in the Mesta power plant a CO_2 recorder without CO or O_2 may lead to conclusion not in accordance with actual operating conditions.

The boiler feed water is heated in an open Cochrane feed water heater. The cooling water from a 400 kw Mesta gas engine and from the Mesta air compressor is collected in a collecting tank and from there pumped to the heater, entering the heater at about 120 degrees F. The make-up cold water is admitted through a float operated valve. Exhaust steam from the Mesta engines in the power house is used for bringing the feed water up to between 200 and 210 degrees F. The amount of exhaust steam is controlled by an exhaust valve of the Cochrane multiple valve type. The exhaust steam not used in boiler feed water heater goes to heating systems of factory.

The feed water is measured by means of a Worthington hot water turbine meter.

Difficulties were experienced in the proper operation of the boilers and equipment. First, owing to the scarcity of good men, and second, owing to the great load variations. It was therefore considered advisable to eliminate the faults gradually. Steam flow meters together with a Hagan regulator were installed and the improvements in the steam pressure can be seen from the pressure charts. The flow meter charts however showed great variations which seemed to occur at practically regular intervals.

After carefully surveying these conditions it was found that the feed water regulating valves were too large, and after the installation of new regulating valves the variations in the flowmeter charts were practically done away with.

A fault common to nearly all regulating valves is the small amount of movement allowed between the closed and full open position.

A complete set of flow meter, pressure and flue gas charts are reproduced and below is given a table showing the performance of the boiler house for February 22, 1921.

Performance data for 24 hours ending February 22, 1921, Mesta Machine Company:

		Pounds
Total steam as measured by Republic flowmeters		1,668,225
Total coal	191,400	
No. 6 boiler banked 9 hours coal for banking	2,000	
Total net coal	——	189,400

Steam pressure	160 lbs. per square inch
Steam temperature	400 degrees F.
Feed water temperature	206 degrees F.
Total heat in steam	1214 Btu per lb. above 32° F.
Heat in feed water	174 Btu per lb. above 32° F.
Actual evaporation per pound of coal	8.81 lbs. of steam
Evaporation from and at 212 degrees F.	9.44 lbs. of steam

The amounts of steam as stated above do not include steam used for blowoffs, soot blowers and stoker engines.

Ratings of Boilers During Period of Steam Generation.

No. of Boiler	Horse-power	Percent rating
4	1008	185
5	892	164
6	700	128

No. 6 boiler took the peak load and consequently was banked during night. The difference in the rating of No. 4 and 5 boilers is due to the fact that the three bottom rows of tubes of No. 4 boiler were turbined on February 17, 1921.

On the Manufacture of Seamless Tubes

A Series of Articles Based on the Origin of Seamless Tube Rolling in Germany, With Special Consideration of the Mannesmann Oblique Rolling Process.

PART II.

By DR. ING. KARL GRUBER,
In Rheydt.

THE roll shown in Figs. 4, 5 and 6 is of the usual design of the Mannesmann oblique rolling mill, for the smallest pattern rolls for hollow rolling solid round bar stock of from 80 to 160 mm diameter.

The largest diameter is $D = 360$ for a body of roll of 500 mm. In addition to this size rolling mills with $D = 450$ or from 550 to 650 are made.

The working taper of length L and inclination angle δ on both sides forms an extension on the right of the largest diameter D (see Figs. 7 and 8). This working taper is of very great importance for the hollow rolling and the theoretical investigation of the rolling process is mainly concerned with this taper. The tangent of the inclination angle usually used has been $\tan \delta = \frac{1}{8}$ to 1/18.

The second factor of special importance is the oblique position of the rolls. Each one of the two rolls which are identical, is inclined at an angle $\beta =$ approximately $\pm$ 5 degrees in relation to the horizontal plane. The center lines when projected on the vertical plane therefore comprise an angle of $2\beta =$ approximately 10 degrees and intersect in the center of the roll.

The point in the center, between the two rolls, that coincides with the projection of the intersection of the roll center lines on to the vertical plane is called the center point M of the Mannesmann rolling mill. All dimensions as to length and width are determined from here and the heights are based on the horizontal plane of the center point which forms the main plane of the rolling mill.

Owing to the oblique position of the rolls, unassisted drawing-in of the bloom between the rolls and automatic feed become possible.

The bloom is not passed in the main plane of the rolling mill but, as Fig. 8 shows, in a plane by the distance h (= 40 mm for small rolling mills) higher up.

The bloom thus would be forced out in an upward direction in the rolling process but for the action of the top roll which prevents it. The latter in this way takes up part of the rolling pressure and forms the closed pass required for hollow rolling. Bottom guidance is not re-

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quired for the ordinary hollow rolling, it is however retained in view of unforeseen conditions.

The rolling in a raised plane is not connected with any particular advantage, on the contrary, the lower end of the roll has to be swivelled round to press against the bloom thus causing the center lines of the rolls to assume a warped orientation.

By raising the bloom and therefore the mandrel, the mandrel rod and the thrust bearing, a more substantial construction of the neck bearings becomes possible.

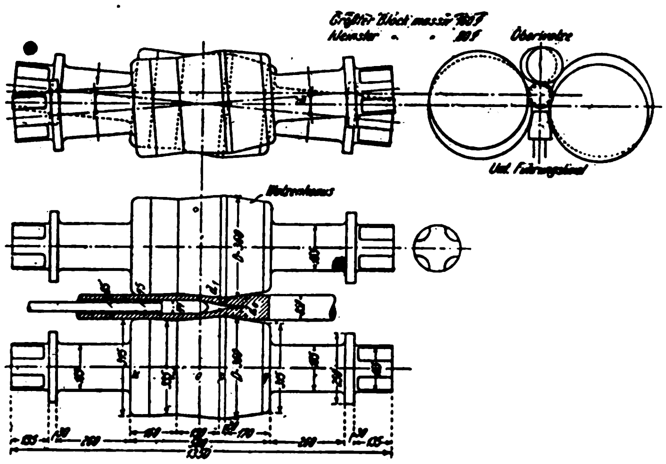
Both rolls rotate in the same direction and at identical speed. The bloom itself must rotate, if viewed in the feeding direction, from the upper towards the lower end of the rolls. In this case it is pulled into the rolls unassisted. The top roll acts as friction roll and assumes the peripheral speed of the main rolls.

Peripheral Speeds of Working Taper of Rolls and of Bloom.

A section in any position of the working tapers of equal diameter D gives a tangential peripheral speed in m per second at n rpm of:

$$v_x = D_x \pi \frac{n}{60}$$

For the same section the diameter of the bloom equals d_x and its speed n_x rpm. The diameter of the bloom diminishes in the tapered part gradually from d_0 to d_1 while the corresponding diameters of roll increase evenly from D_0 to D_1 As a consequence the speed of the bloom is increasing very rapidly from n_0 to n_1



Figs. 4 to 6.

The variable n_x can be obtained from the equation

(compare Fig. 8a: $d_x \pi \frac{n_x}{60} = v_x \cos\beta$; $n_x = \frac{60\, v_x \cos\beta}{d_x \pi}$

$$n_x = \frac{D_x}{d_x} \cos\beta \; n \qquad (1)$$

On the assumption that the feed of the bloom equals the horizontal velocity component v sin β of the roll circumference, the feed rate per revolution (compare Figs. 8a and 9) is obtained as follows:

$$s_x = \frac{v_x \sin\beta}{n_x} 60 = \frac{v_x \sin\beta}{v_x \cos\beta} d_x \pi$$

$$s_x = d_x \pi \tan\beta \qquad 2$$

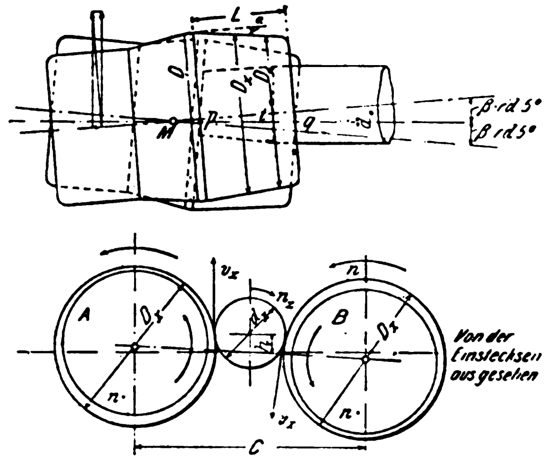
This feed rate per revolution corresponds to the pitch of the helical line on the bloom taper.

If the rolling mill is designed for a given angle β, then the pitch s_x is proportional to the diameter:

for $\beta = 4°$ or $\tan\beta = 0.07$; $s_x = 0.22\, d_x$

for $\beta = 5°$ or $\tan\beta$ 0.0875; $s_x = 0.275\, d_x$

The movement of the bloom therefore resembles that of a conical screw which is passing between the rolls with the thread being renewed all the time. As soon as the resistance of the mandrel has to be overcome by the bloom, the speed of the latter is kept up while the pitch decreases. The helical lines have a more shallow shape, and this is particularly the case when the end of the bloom enters the rolls, the hollow then being formed with difficulty only.



Figs. 7 and 8.

Mention has to be made of the fact that, owing to the position of the center line of the bloom being raised over the main center plane, small deviations as regards the movements are set up which, however, are of no practical importance. For instance, in one circular section of the bloom the circumferential speed on one side becomes smaller, by a slight amount, than that on the other side. In this instance the top roll effects on equalization, in as much as slip occurs so that an average speed is set up.

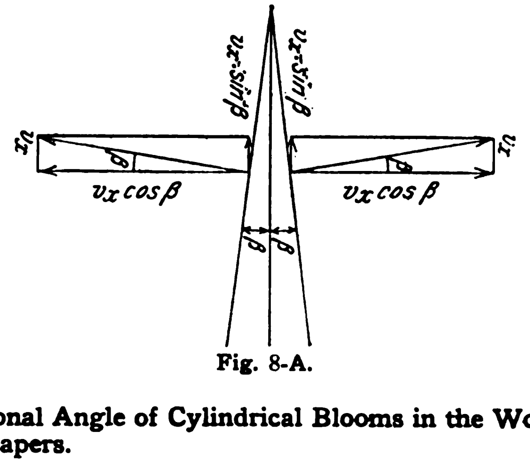


Fig. 8-A.

Torsional Angle of Cylindrical Blooms in the Working Tapers.

As soon as the solid bloom has been pulled in by the rolls, it assumes the speed n_0, as follows:

$$n_0 = \frac{D_0}{d_0} \cos\beta \; n.$$

This number of revolutions per minute is constantly

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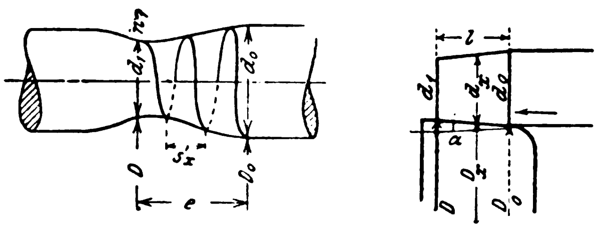
increased until, with the smallest diameter d, and the largest diameter of roll D it becomes:

$$n_1 = \frac{D}{d_1} \cos\beta \; n$$

The number of revolutions per second increases evenly from $\frac{n_0}{60}$ to $\frac{n_1}{60}$ It follows that for each second of the rotary movement a lead of the smaller cross section takes place, as follows: $\frac{n_1 - n_0}{60}$

This lead can be expressed in angular degrees and the following angle is obtained: $\frac{n_1 - n_0}{60}$ 360 degrees.

The feed movement of the bloom, from the time of first contact to when the smallest cross section is reached, takes the time t in sec. and the angle assumes a definite value as follows: $\delta = \frac{n_1 - n_0}{60} \, 360 \, t$ (3)

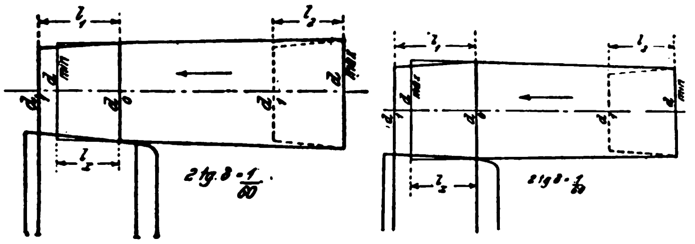


Figs. 9 and 9-A.

As long as the time t of the transition from d_0 to d_1 remains constant, the value of the torsional angle remains the same.

The torsional angle can be taken as the measure of the formation of the hollow, i.e. to a given angle δ corresponds a definite ratio formed by the inside width and the smallest diameter δ of the taper.

It therefore becomes necessary to determine more accurately the value of δ from the dimensions of the rolls and the bloom, and from the inclination angles δ and β.



Figs. 10 and 11.

For this purpose the time t has to be ascertained first. The length l of the bloom taper (see Fig. 9a) equals:

$$l = \frac{D - D_0}{2 \tan \delta} = \frac{d_0 - d_1}{2 \tan \delta} \qquad (4)$$

The velocity in the lengthwise direction of the bloom, i.e. the feed rate per sec., is for any part:

$$c = v_x \sin\beta ; \; c = D_x \pi \frac{n}{60} \sin\beta .$$

The increase of the velocity c therefore varies within the limits:

$$c_0 = D_0 \pi \frac{n}{60} \sin\beta ; \; c_1 = D \pi \frac{n}{60} \sin\beta .$$

The average value becomes thus:

$$c = \frac{c_0 + c_1}{2} = \frac{D + D_0}{2} \pi \frac{n}{60} \sin\beta \qquad (5)$$

The time t is obtained by dividing the equations 4 and 5:

$$t = \frac{l}{c} = \frac{d_0 - d_1}{D + D_0} \cdot \frac{1}{\pi \frac{n}{60} \sin \beta \tan \delta} \qquad (6)$$

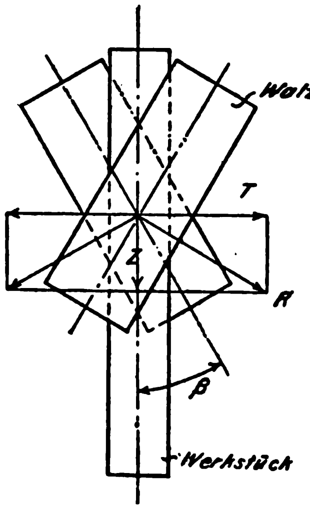


Fig. 12.

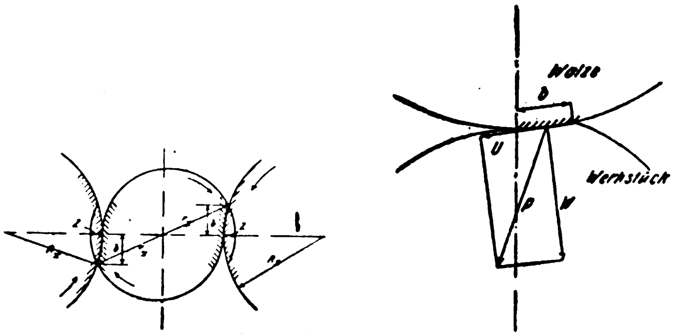
From the above equation giving n_0 and n_1 immediately follows:

$$\frac{n_1 - n_0}{60} \left(= \frac{D}{d_1} - \frac{D_0}{d_0} \right) \frac{n}{60} \cos\beta \qquad (7)$$

By inserting the values (6) and (7) into equation (3) the value for the torsional angle is obtained as follows:

$$\delta = \left(\frac{D \quad - \quad D_0}{d_1 \qquad d_0} \right) \left(\frac{d_0 - d_1}{D + d_0} \right) \frac{360}{\pi \tan \beta \tan \delta} \qquad (8)$$

$$\delta = \frac{D \left(\frac{d_0 - d_1}{d_1} \right) - D_0 \frac{d_0 - d_1}{d_0}}{D + D_0} \; \frac{360}{\pi \tan \beta \tan \delta} \qquad (8)$$



Figs. 12-A and 12-B.

This equation comprises all factors which influence the torsional angle δ and consequently the formation of the hollow. The second element containing the angles δ and β is a constant for a given rolling mill.

In Mannesmann rolling mills of a roll diameter of 360 mm, the angle β usually equals 5 degrees. The angle δ, however, varies a good deal and, for instance, for δ = 4 degrees, we obtain:

$$\frac{360}{\pi \tan \beta \tan \delta} = \frac{360}{3.14 \times 0.0875 \times 0.07} = \frac{360}{0.01925}$$

and for $\delta = 7$ degrees:

$$\frac{360}{3.14 \times 0.0875 \times 0.1228} = \frac{360}{0.03377}$$

The torsional angles for these two values will therefore show a considerable difference.

The values for

$$\frac{D\left(\frac{d_0 - d_1}{d_1}\right) - D_0\frac{d_0 - d_1}{d_0}}{D + D_0} = E;\ D = 360 \text{ mm}$$

$D - D_0 = d_0 - d_1$, so that D_0 can be ascertained; $d_0 = 80$ or 160 mm diameter of bloom.

Table 1—Clearance and Torsional Angle.

$\frac{d_0 - d_1}{d_0}$	0.05	0.10	0.15
$\frac{d_0 - d_1}{d_0}$	$\frac{4}{80}$	$\frac{8}{80}$	$\frac{12}{80}$
E	0.00160	0.00674	0.01600
$\frac{d_0 - d_1}{d_0}$	$\frac{8}{160}$	$\frac{16}{160}$	$\frac{24}{160}$
E	0.00189	0.00796	0.01887

From Table 1 can be seen that as the clearance angle of the roll increases the value E, and consequently the torsional angle increase as well.

If, through altering the clearance angle, $d_0 - d_1$ is increased to three times its value then the value of E rises to 10 times the former amount.

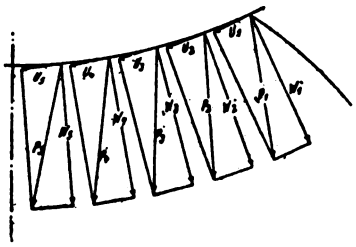


Fig. 12-C.

In rough approximation this can be stated thus: The torsional angle and consequently the formation of the hollow is increasing as the *square* of the clearance of the rolls.

This contains the essentials for controlling the hollowing process. The rolls are to be so adjusted that a sufficient hollow forms to enable the hollow bloom to be pushed over the mandrel easily while insuring a smooth interior surface. Should the mandrel offer too much resistance, then the rolls have to be set closer in order to produce a larger hollow.

Equation No. 8 is based on the assumption that the bloom is passing through the rolls without finding a resistance. If this, however, is not the case, but if the mandrel is offering a considerable resistance, the speed may be only half that shown, and the time twice as long as for a free passage. The value δ of the horizontal angle must not be changed by this. In such case the torsional angle must be set, from the beginning, to half the size.

This deviation from a free passage is particularly frequent when the end of the bloom has reached the rolls. In that case the formation of a hollow, towards the end, is impossible and the resistance of the mandrel assumes a considerable maximum value. This is a drawback of the hollow rolling process, necessitating a very marked additional amount of power towards the end of the pass of which more anon.

4. *Torsional Angle of Taper Ingots*—The previous paragraph has been dealing with the hollowing of rolled (very homogeneous) mild steel round bar of from 80 to 160 mm diameter. In addition taper ingots of from 130 to 450 mm diameter at the base and a length of from 1000 to 1200 mm are being hollow rolled. The top of the ingots is about 15 mm less in diameter. On account of this slight taper it will sometimes be difficult to strip the ingots, but the taper must be very slight as otherwise the effect on the torsional angle δ becomes very marked.

The angle δ is least for the small end of the ingot and assumes 2 to 2¼ times this value for the big end. As a consequence there will be a tendency to form an uneven hollow. At all events very considerable variations of the mandrel resistance will become noticeable.

In order to be able to shape the rolls correctly, the length of the line of contact between the ingot and the working taper of the rolls must be determined.

To begin with, the assumption shall be made that the big end of the ingot is inserted into the rolls. See Fig. 10.

If the small inclination angle between the side line of the ingot and its axis be called δ, we obtain:

$$d_0 = d_1 + 2\,l_1 \tan\delta,$$

on the other hand, the following obtains:

$$d_0 = d_{max} - 2\,l_x \tan\delta$$

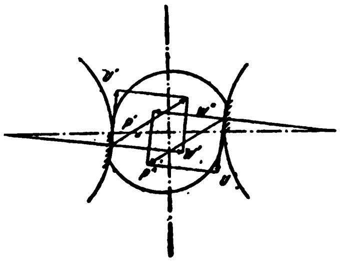


Fig. 13.

The two truncated cones of the lengths l_1 and l_x respectively possess identical volumes which under the circumstances can for the present be assumed to be $l_x = 0.9\,l_1$. From the two equations for d_0 the following is obtained:

$$l_1 = \frac{d\ \max - d_1}{d\ (\tan\delta + 0.9\tan\beta)} \qquad (9)$$

This result can now be used for checking l_x more accurately. Thus we obtain for the back end of the ingot:

$$l_2 = \frac{d_{min} - d_1}{2\tan\delta} \qquad (10)$$

For the diameter d_1 a value is selected which is large enough to provide for a diminuition of the ingot diameters of the two ends of from 0.05 to 0.15 of the corresponding diameters. From l_1 and d_1 the value for d_0 can be obtained. In this way all dimensions have been found.

Now the small end of the ingot is to be inserted into the rolls first (compare Fig. 11). Changing the signs we obtain:

$$d_0 = d_1 + 2\,l_1 \tan\delta$$

and

$$d_0 = d_{min} + 2l_x \tan\delta$$

from which, if again l_x is assumed for the present to equal 0.9 l_1 results:

$$l_1 = \frac{d_{min} - d_1}{2\ (\tan\delta - 0.9 \tan\delta)} \qquad (11)$$

and for the big end of the ingot:

$$b_2 = \frac{d_{max} - d_1}{2 \tan\delta} \qquad (12)$$

The value of d_1 to be taken as above when d_0 can be worked out.

Example: A round taper ingot of 450 and 430 mm diameter and 1200 mm length is to be hollow rolled. The largest diameter of roll is D = 550 mm

$$d_{max} = 450 \text{ mm};\ d_{min} = 430 \text{ mm}$$

$$\tan\delta = \frac{10}{1200};\ \tan\delta = \frac{1}{15};\ d_1 = 400 \text{ mm}$$

1. Big end in front: Equations (9) and (10)

$$l_1 = \frac{450 - 400}{\left(\frac{1}{15} + 0.9\ \frac{1}{120}\right)} = 337.4 \text{ mm}$$

$$l_2 = \frac{430 - 400}{2 \times \frac{1}{15}} = 225 \text{ mm}$$

$$d_0 = 400 + 2 \times 337.4 \times \frac{1}{15} = 445 \text{ mm.}$$

The two values of the torsional angle δ can now be worked out as per equation (8) for $\tan\delta = \frac{1}{15}$

at the start:

$$\delta_1 = \frac{550 \times \frac{45}{400} = 505 \times \frac{45}{445}}{550 + 505} \times \frac{360}{0.01833}$$

$$\delta_1 = 0.0102 \times \frac{360}{0.01833} = 196.40$$

and at the finish:

$$\delta_2 = \frac{550 \times 30/400 - 520 \times 30/430}{550 + 520} \times \frac{360}{0.01833}$$

$$\delta_2 = 0.00467 \times \frac{360}{0.01833} = 91.7^{\circ}$$

2. Small end in front; equations (11) and (12)

$$l_1 = \frac{430 - 400}{2\left(\frac{1}{15} - 0.9 \times \frac{1}{120}\right)} = 253.8 \text{ mm}$$

$$l_2 = \frac{450 - 400}{2 \times \frac{1}{15}} = 375 \text{ mm}$$

$$d_0 = 400 + 2 \times 253.8 \times \frac{1}{15} = 433.8 \text{ mm}$$

The two corresponding values of the torsional angle δ are obtained in the same way as shown above:
at the start:

$$\delta = \frac{550 \times \frac{33.8}{400} - 516.2 \times \frac{33.8}{433.8}}{550 + 516.2} \times \frac{360}{0.01833}$$

$$\delta_1 = 0.00587 \times \frac{360}{0.01833} = 115.3^{\circ}$$

and at the finish:

$$\delta_2 = \frac{550 \times \frac{50}{400} - 500 \times \frac{50}{450}}{550 + 500} \times \frac{360}{0.01833}$$

$$\delta_2 = 0.01257 \times \frac{360}{0.01833} = 246.9^{\circ}$$

The above shows in figures that the ingots behave very differently. In both cases the difference is very considerable for the two ends.

Still, probably the big end of the ingot will preferably be inserted into the rolls because pipe that may be present at the upper, small end of the ingot exerts a desirable influence on the hollow rolling in that case.

So far, in working out the tangential speeds and also the torsional angle, the slip which occurs between roll and specimen has not been considered. *The transmission of motion from the rolls to the specimen is bound to be irregular inasmuch as, through sliding friction, retardation will occur while, on account of the rolling process, in a certain sense a lead will take place. The horizontal velocity, i.e., that in a lengthwise direction of the specimen, is also influenced by the friction set up between roll and specimen through the forward travel of the molecules in the direction of the axis.* It is therefore really necessary to introduce coefficients into the calculations which take these factors into consideration; they have, however, been omitted here.

5. *Effect of Forces*—Before starting hollow rolling the rolls have to be properly set or adjusted. After the ingot has been gripped by the rolls, it is pulled through without outside assistance. The working surfaces between rolled piece and roll which we propose to call rolling surface for short are also formed unaidedly. There is further the friction R, a force which is set up by the pressure between roll and specimen and which forms a normal on the axis of the roll (see Fig. 12). This friction R acts on the specimen by its two components $T = R \cos\beta$ and $Z = R \sin\beta$.

The force, coupled with the pressure of the rolls, effects the tangential shifting of the surface molecules of the specimen which has been brought to welding heat and is in a plastic condition.

The force Z effects a shifting of the surface molecules in a direction parallel to the axis of the specimen as the roll taper resists the movement of the specimen as a whole.

The resistance of the mandrel does not figure at the beginning of the rolling period. The effect of the two forces mentioned above is to shift the molecules of the material spiral shape.

While the ingot is moving through a spiral line its diameter is decreasing. The decrease of the ingot taper, in any point of the surface, equals 2z (compare Fig. 12a).

Now, the area of the rolling surface can be worked out, as the following relation obtains:

$$2z : (d_0 - d_1) = s_x : 1$$

With s_x from equation No. 2, and assuming

$l = \frac{d_0 - d_1}{2 \tan\delta}$, we obtain:

$$2z = (d_0 - d_1) \frac{d_x \pi \tan \beta}{\frac{d_0 - d_1}{2 \tan \delta}}$$

$$z = d_x \pi \tan \delta \tan \beta \qquad (13)$$

This means that in a given rolling mill the decrease of diameter per revolution of the ingot is proportional to the diameter of the latter.

From Fig. 12a the rolling width b can be determined in the following way for any point on the surface:

$$z = R_x - \sqrt{R_x^2 - b^2} + r_x - \sqrt{r_x^2 - b^2}$$

$$z = R_x \left(1 - \left[1 - \left(\frac{b}{R_x}\right)^2\right]^{1/2}\right) + r_x \left(1 - \left[1 - \left(\frac{b}{r_x}\right)\right]^{1/2}\right)$$

$$z = R_x \times \frac{1\ b^2}{2\ R_x^2} + r_x \times \frac{1\ b^2}{2\ r_x^2}$$

$$z = \frac{1}{2} b^2 \left(\frac{1}{R_x} + \frac{1}{r_x} \right)$$

$$b = \sqrt{\frac{2z\ R_x r_x}{R_x + r_x}} \qquad (14)$$

After inserting the diameter, we obtain for the beginning and the end of the ingot taper:

$$b_1 = \sqrt{\frac{z_1 D_0 d_0}{D_0 + d_1}} \qquad (15)$$

$$b_2 = \sqrt{\frac{z_0 D d_1}{D + d_1}} \qquad (16)$$

The rolling surface thus possesses an average width of $\frac{b_1 + b_2}{2}$ and a length which is equal to that of the ingot taper 1.

As soon as the diameter stops decreasing, tan δ becomes 0 and therefore $z = 0$ as well.

The pressure exerted on the rolling surface then ceases.

The rolling pressure, therefore, is $W = 1 \times \frac{b + b_2}{p} \times p$.

The specific surface pressure p is dependant on the strength and the temperature of the material. In order to select a definite figure for the pressure p per sq. mm of the rolling surface, the tests of Puppet* give useful hints. From the results of experiments when passing a 2500 kg ingot through a cogging mill, the specific pressure in the plane of contact between roll and ingot can be calculated and amounts to from 4 to 13 kg per sq. mm according to the number of passes. In our case we can assume an approximate value of from 5 to 10 kg, depending on the size of the ingot and taking the lower figures for the larger, the higher figures for the smaller ingots.

The force W thus represents the pressure by which the hard roll constantly acts on the plastic material of the specimen which has been brought to welding heat.

The whole process can be compared to a hard roll rolling over a soft material in a similar way in which a wheel rolls on yielding ground.

Roll and specimen are in contact along an arc or rather part of a narabola (rolling surface), all the pressures being distributed over this length. The resultant of all the single pressures must pass through the center of neck if the latter is smooth. Its horizontal component can be obtained from the equation: $\frac{U}{W} = \frac{b/2}{R_x}$ (see Figs. 12 b and c). From this follows $U = W \frac{b}{2R_x} \times \frac{b}{2R_x}$ which represents the coefficient of the rolling friction.

This force U has to be overcome by the power drive of the rolling mill, in addition, of course, to the friction of the necks which is caused through the rolling pressure. Now, if we plot the resultant of all these forces P_1, P_2 .. P_5 on the diagram of the rolling mill, then the forces P′ and P″ form a couple which effects the rotation of the specimen round its longitudinal axis, while the transformation of the same is going on at the same time (see Fig. 13). The rolls being inclined towards each other, the forces P′ and P″ do not fall in the plane of the cross section but towards a third direction in space and can be split up into two components T′ and T″, one of which has the direction of the axis of rotation of the specimen, while the other is normal to it. The sum of the first component is marked with the letter Z in Fig. 12 and, as mentioned, causes the movement of the surface molecules of the specimen in the direction of the longitudinal axis, if the specimen itself is held back by some resistance, as in our case by the ingot taper. The sum of the second component, called T, acts on the surface normally to the axis of rotation of the specimen. The forces Z and T produce first of all the spiral shape progressive movement of the surface molecules which is transmitted to the interior of the specimen.

(Continued in May issue)

CONVENTION AND EXHIBITION OF AMERICAN SOCIETY FOR STEEL TREATING.

The board of directors has decided to hold the third annual convention and exhibition of the American Society for Steel Treating during the week of September 19 to 24, inclusive, at Indianapolis.

Before arriving at this decision, the board gave various consideration to the many invitations received. Because of the enormous size to which the exhibition has grown there are very few cities having a sufficiently large building capable of accommodating the exhibition.

Indianapolis was fortunate in having on the State Fair Grounds, the Manufacturers' Building, 360 feet in length by 220 feet in width, the total floor area of which is 76,800 square feet. The central section of this building measuring 240 feet by 100 feet, is known as the "Sunken Garden," and is 20 inches below the level of the surrounding floor space. The building is new, well lighted, and excellently adapted for exhibition purposes. The management has divided the floor space into one hundred and sixty-one 10 feet by 20 feet sections. The booths along the north wall are to be used for the live exhibits and are supplied with gas and compressed air, while arrangements have also been made for the exhibitors who require heavy electrical current to be on the promenade on the same side of the building. The floor plan was ready for distribution on March 15 and reservations can now be made.

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*Stahl und Eisen 26 V. 1910, p. 182,617.

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New Controlling Valve for Open Hearths

Description of a New Type Valve for Supplying Air and Gas Mixtures to Open Hearth Furnaces, Resulting in Marked Fuel Economy and Greater Regenerative Efficiency.

By **W. H. WHARTON,**
Consulting Engineer, Canadian Allis-Chalmers, Ltd.

PRESENT day conditions are compelling all industrial plants to give strict attention to the questions of economy and efficiency. More especially does this apply to our large steel plants in which tremendous amounts must be continuously handled and enormous quantities of fuel of various kinds consumed in production and conversion of this material. During the last fifteen years excellent progress along these lines has been made in all steel plants, and while the results achieved might with justification be regarded as very satisfactory, there still remain many directions in which improvements might be accomplished.

There is one branch of our large steel industries which has, from a fuel economy point of view, remained almost at a standstill and is to-day in but a slightly better position than when the open-hearth method of melting steel was first introduced by Siemens and Martin. This fact is the more remarkable in the light of advancement made in almost every other branch of the steel industry.

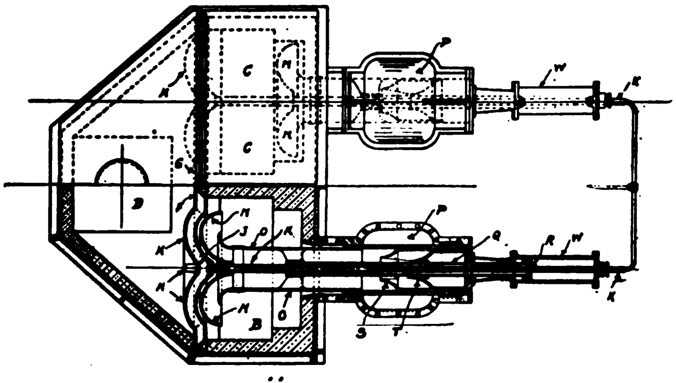


FIGURE 1

It is unnecessary to dwell in detail on the almost revolutionary changes that have been made during recent years in the coke-oven and blast-furnace practices, the very importance of which has compelled every steel man to familiarize himself with the details. The methods of rolling and handling large quantities of steel have advanced by leaps and bounds as also have the technical considerations involved in the manufacture and physical treatment of the material until a high state of efficiency and economy has been achieved, and yet, in the midst of all this advancement the fuel economy and efficiency of the open-hearth furnace has practically remained at a standstill. Some advancements have certainly been made in the preparation and production af gaseous fuel, but the actual consumption of these fuels after preparation is as wasteful as ever. The regrettable condition is probably due to several underlying causes. Possibly one of the reasons is that attention has been wholly concentrated on the metallurgical problems of open hearth practice and not without excellent results. Possibly the chief reason has been the lack of coöperation between the engineers designing open-hearth furnaces and their accessories, and the open-hearth superintendents and others, in charge of the actual operation of the furnaces, with the result that each has pursued his own course, regardless of, or oblivious to the opinions and ideas of the other.

It is pleasing to note, however, that during the past few years these prejudices have to some extent been overcome, a different attitude being demanded towards this question by the fuel stringency of recent years. As an illustration of this change of attitude, may be cited the recommendation passed at a recent meeting of the Open-Hearth Committee of the Carnegie Steel Company, one of which was to the effect that a furnace should be built apart from the rest with facilities and space to allow of the carrying out of experiments in the improvement of the ports of open-hearth furnaces, the use of removable slag pockets and the volume control of the air-supply. While each of these features demands careful and immediate consideration, it is upon the last that the greatest efforts should be concentrated. Very few of our furnace installations achieve anything near perfect combustion, in fact few exist that are using less than 50 per cent excess air. Some idea of the loss of heat units incurred may be obtained by a brief consideration of this point;

1 pound of coal forms roughly 4.34 pounds of gas. This amount of gas requires 4.86 pounds of air to form complete combustion.

Heat units (Btu) in 1 pound of coal = 12,500.

Heat units consumed in heating necessary air to temperature of melting furnace:

$$4.86 \times 3{,}000 \times .25 = 3{,}640 = 29.1\%.$$

Heat units (Btu) consumed when using 50% excess air: $729 \times 3{,}000 \times .25 = 5{,}470 = 43.7\%$, a difference representing a loss of 14.6%.

Now consider this loss in connection with the production of a 50-ton heat of steel. Under moderate furnace conditions, the consumption of coal ranges anywhere from 500 to 700 pounds per ton of steel made. Assume an average of 600 pounds. Therefore the loss on one heat of 50 tons

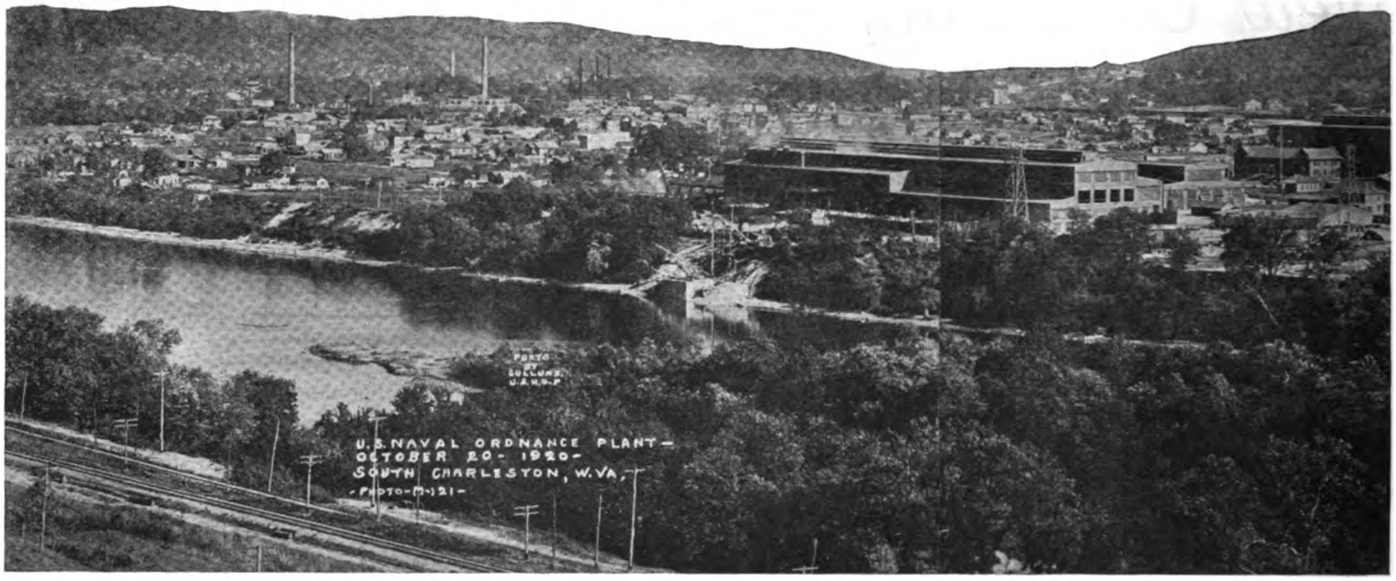
$$= \frac{14.6 \times 600 \times 50}{100} = 4{,}380 \text{ lbs.}$$

Annual loss on each 50-ton furnace producing 16 heats per week:

$$16 \times 52 \times 4{,}380 = 3{,}744{,}160 \text{ lbs.}$$

Now consider the cause of this loss; imperfect combustion, due to inadequate control of the incoming gases, and the use of furnace ports combined with incorrect draft arrangement which prevent, or at least

(Continued on page 280)



General View of the U. S. Naval Ordnance Plant from the right bank of the Kanawha River.

United States Naval Ordnance Plant

A Description of the New Plant Recently Constructed at Charleston, West Virginia—Engineering Features of the Open Hearth in Detail.

By **WILLIAM J. PRIESTLEY,**
Steel Superintendent.

PART I.

THE earliest recorded suggestion for armor for fighting ships seems to have been made in 1805 by Sir William Congreve, an Englishman.

Records show that in 1812, an American by the name of John Stevens of New Jersey, submitted to Congress, plans for an iron clad vessel. Nothing definite, however, seems to have resulted from this proposal until 1841, when it was determined by actual experiment the thickness of wrought iron required to resist the attack of the projectiles then in use.

The first floating batteries were laid down by the United States, England, and France in about 1854.

The earliest armor used was made of wrought iron, sometimes of single thickness and frequently in successive layers of wood or concrete. As time went on, improvements were made in the penetrating qualities of projectiles, and steel instead of wrought iron was used to procure the necessary increased resistance. The race between the armor plate-maker and the armor piercing projectile-maker had now started and has continued for more than half a century.

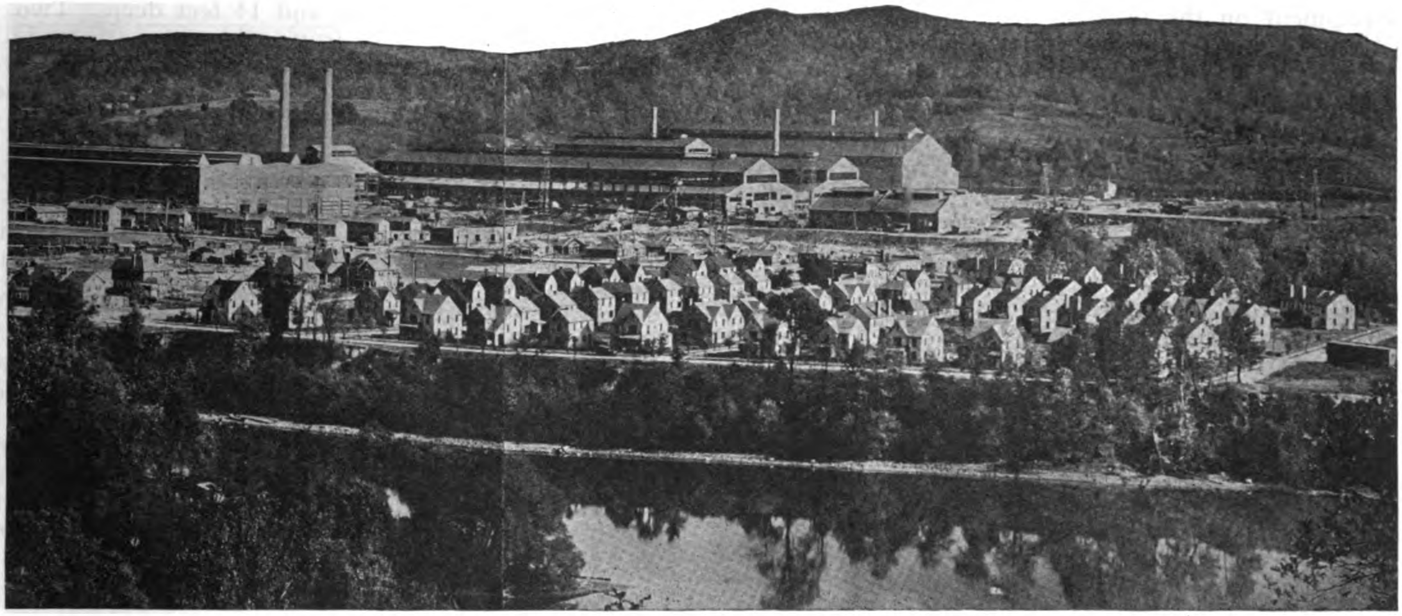
The Bethlehem Iron Company commenced the manufacture of armor in 1888. Harvey armor, which consisted of cementing and subsequently hardening one face of a nickel steel plate, was introduced in 1891. With the development of the capped projectile, armor plate offering greater resistance than that produced by the Harvey process had to be developed.

In 1898, the Krupp process of making armor plate was introduced into this country. It was found that by the introduction of chromium into the steel along with the nickel, a tougher back and stronger face might be produced. Since that time, various modifications have been made in chemical analysis, method of forging, heat treatment and physical properties of armor plate, but no marked change had been made in all these years in the method of melting or making the steel of the high quality that is necessary for ordnance material.

This fact was never forcibly brought home to the many steel-makers of the country until the war, when scores of plants were turned over to the government, for the manufacture of gun forgings, projectiles, and other ordnance material. In the building of battleships and ordnance material, where every surplus pound of material used is an impediment in action, the best quality of steel is paramount.

At the present time, the armor piercing projectile has a decided advantage over the armor plate. Steel manufacturers have always looked upon the ordnance branch of their business as "hazardous," and consequently, have not been inclined to expend the same amount of money in experiment as in other branches of their business. The Navy department has long been aware of this situation and this was one of the principal reasons for building a Steel Plant of its own where standards of quality could be set, without restraint of the problems confronting private manufacturers.

The advent of the electric melting furnace, with its greater flexibility of operation over the basic and acid open-hearth furnaces, seemed to offer a starting point



Kanawha River in the foreground; C. & O. R. R. in the background at the foot of the hill.

for the higher grade product desired by the Navy. The accuracy of this assumption has already been proven after the first year of operation of a navy owned plant. At the present writing, the navy operated plant at South Charleston, West Virginia, has made 16-inch armor piercing projectiles, torpedo air flasks and gun forgings which have surpassed all tests made by private manufacturers.

Location and Facilities.

The United States naval ordnance plant is located on the left bank of the Great Kanawha River, about five miles west of the city of Charleston, and also on the main line of the Chesapeake & Ohio Railroad. Situated in the very center of the great bituminous coal, natural gas, and oil fields of West Virginia, the plant possesses many advantages for economical operation with which most steel plants are not favored. The proximity of the plant to the base of refractories in Kentucky and Ohio also afford it various advantages.

The government reservation covers approximately 200 acres and is divided into two Units. The North Unit, built in 1918, is laid out and equipped for the manufacture of large caliber armor piercing projectiles, gun forgings up to and including 6-inch bore, 21-inch torpedo air flasks, ship shafting, armor plate bolts and nuts, and miscellaneous battleship and mount forgings. The South Unit, built in 1919 and 1920, is laid out and equipped to make battleship armor plate and large caliber gun forgings up to 20-inch bore.

Source of Power.

The electric power used for operation of the plant is at present supplied from two sources. The West Virginia Water & Electric Co. of Charleston supplies the North Unit with 5,000 kw at 2200 volts. The Virginian Power Company of Cabin Creek, supplies 22,000 kw additional power for the South Unit. The latter is delivered over two high tension transmission lines at 66,000 and 44,000 volts, from a coal-operated plant, in the heart of the bituminous coal fields, about fifteen miles up the Great Kanawha River. Located at this place is a 20,000 kw generator, with 7460 hp Babcock-Wilcox boilers, originally installed by the government during the war for furnishing power to the large powder plant at Nitro. This has come into the possession of the navy for use in operating the Naval ordnance plant at South Charleston.

Fuel.

One of the economic reasons for locating the plant in West Virginia, was the advantage of using natural gas as a fuel. The total requirements for operating both North and South Units amount to approximately 6,000,000 cubic feet of gas per day. This natural gas is furnished by the Charleston-Dunbar Natural Gas Company. The navy has first call on 15,000 acres of proven territory in Kanawha, Putman, and Logan counties. The gas, which has a calorific value of 950 to 1000 Btu is received at about 50 pounds pressure through an 8-inch pipe line.

At the present time, coal is used principally in the boiler plant and yard locomotives. This is delivered from local fields over the Chesapeake & Ohio Railroad. At a later date, when it may become necessary to resort to artificial gas for firing the furnaces, coal used for this purpose may be unloaded from barges on the Kanawha river. The consumption of coal at this time does not warrant the erection of a dock or unloading wharf.

Water Supply.

The plant has two sources of water supply. A pump house has been erected on the Kanawha river for taking care of cooling water for furnaces and fire protection. This consists of two 2,000 gallon per minute centrifugal pumps which deliver water through a 30-inch tile pipe embedded in concrete to a large settling basin of about 25,000,000 gallon capacity. As the plant uses about 5,000,000 gallons per day for cooling purposes, this provides for a five-day's reserve of clear settled water. From the settling basin the water is delivered to a large standpipe 24 feet in diameter and 120 feet high, containing 400,000 gallons. This tank is made of 1-inch plates at the bottom, ¼-inch plates at the top. In case of emergency, the water in the standpipe alone would accommodate the cooling

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equipment on the furnaces four or five hours. The West Virginia Water & Electric Co. furnishes 375,000 gallons per day for domestic purposes and emergency storage in case of fire or breakdown of the other system owned and operated by the ordnance plant. A small distillation plant has been erected for supplying drinking water.

Description of Manufacturing Equipment.

Having mentioned in a general way the purpose of the plant and its service utilities, it is now proposed to present to the reader, a more detailed description, than has heretofore been published, of the equipment and apparatus used in the making of the large and heavy ordnance material enumerated in the introductory paragraphs. It is not proposed to enter into the processes or methods of making armor plate, guns or projectiles, at this time.

Therefore, the equipment used in making and heat-treating the steel will be described not in the sequence used for any particular article, but will be divided under the three groups, as follows:

Melt Shops—Number One, Number Two.
Forge Shops—Number One, Number Two.
Heat Treatment Shops—Number One, Number Two, Number Three, Number Four.

Melt Shop No. 1.

Melt Shop No. 1, in the North Unit, is located in the west end of the Forge and Foundry building, which is about 130 feet wide and 560 feet long. The main bay is 75 feet wide and is served by two overhead traveling cranes, 35 and 20 ton respectively. The former has a 5-ton auxiliary hoist.

At present, there are three 6-ton basic standard type Heroult electric melting furnaces in this shop, melting cold scrap salvaged from other navy yards and stations. The furnaces operate with alternating current of 110 volts, which is stepped down from 2200 volts through a separate transformer of 1500 kva capacity on each furnace. The furnaces are equipped with Thury regulators for operating the 17-inch amorphous carbon electrodes. Roof rings, electrode holders and skewbacks are water cooled.

The furnaces are hand charged with cold scrap, which is delivered on scales from the stockyard, parallel to and north of the melt shop. The accompanying photograph, Fig. 8, taken from the east end of the stockyard, shows the arrangement of bins, method of handling scrap with electric magnet and 5-ton overhead traveling crane, and means of loading on scales placed on a transfer car. Note how carefully scrap, turnings, and raw materials are segregated, and method of labeling bins. This careful segregation of carbon, nickel, and nickel chrome, scrap and other raw materials, is a practice that will repay any melt shop working on various grades of alloy steels.

The charging floor is elevated 12 feet above the ground level. This offers greater ease in slagging off, and caring for the furnace mechanism, than if the furnaces were in pits in the ground.

Steel for 16-inch armor piercing projectiles, 6-inch gun forgings, 21-inch torpedo air flasks, 16-inch mount counter recoil cylinders, is melted in the three 6-ton furnaces and cast into ingots weighing, 1, 3, 6, 12 and 18 tons each. Steel castings for construction of the South Unit were made here; also, all castings for repairs and maintenance.

Steel is cast in iron molds, placed in a pouring pit 7 feet wide, 24 feet long and 14 feet deep. Two to three heats per furnace from cold scrap are made in 24 hours, using about 900 kwh per ton of steel produced. 17-inch amorphous carbon electrodes are used with a consumption of about 36 pounds per ton of cold scrap melted.

As quality is more important than quantity on high grade ordnance steel, the furnace men are encouraged to be most particular with their melting practice. Special attention is paid to the temperature at which the steel is placed in the molds. The regularity of this practice is evidenced by the long life of roofs and side walls. It is customary to get from 115 to 125 heats from the lining and roof of a furnace without patching during the campaign. This is on cold melting. A very close record of each heat is kept so that reference may be made at any time after forging or heat treatment, and results verified if anything out of the ordinary occurs in final tests. This is a system that every steel plant could well afford to adopt.

Iron Foundry.

In this same building, two 60-inch Whiting cupolas, are located east of the electric furnaces. These are used for making ingot molds, dies, jig and furnace castings, etc. for the rest of the plant.

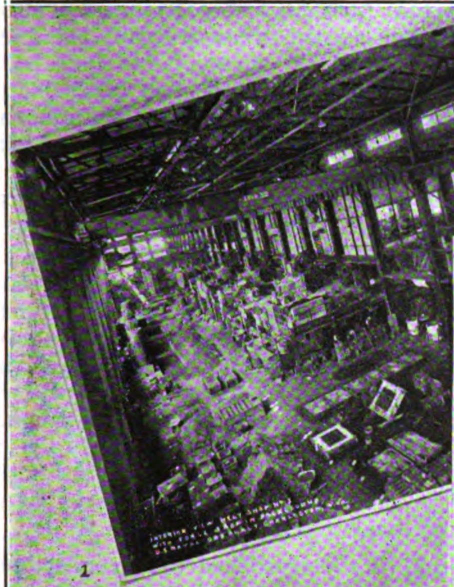
The photographs, shown of the U. S. Naval Ordnance Plant, on the next page are descriptive of the following:

Fig. 1—Interior view of Melt Shop No. 1, showing 6-ton Electric Furnaces in middle of picture.
Fig. 2—First heat of steel being poured into 40-ton electric for refining.
Fig. 3—First armor plate ingot being cast — Note, method of bridging large casting pit around ingot mold.
Fig. 4—Charging Floor of Melt Shop No. 2. Storage bins for raw materials in the distance.
Fig. 5—First heat of steel being tapped from open hearth furnace.
Fig. 6—View of 6-ton Electric Furnace being tapped.
Fig. 7—View of Pouring Aisle in Melt Shop No. 2. Open hearth furnaces in middle of picture. 40-ton Electrics to the left of the picture, behind transformer house.
Fig. 8—View of stockyard. North of No. 1 Melt Shop. Note—arrangement of bins for segregation of raw materials.

Brass Foundry.

A small brass foundry consisting of two 300-pound tilting natural gas fired furnaces, supply metal for bearings, bushings, valve seats, etc. for the other departments of the plant. Two large natural gas fired carbottom drying ovens 32 feet long by 10 feet wide by 8 feet high are used for drying cores and sand molds.

A one-ton Heroult electric melting furnace located west of the three 6-ton furnaces on the same charging floor level is used for remelting tool steel salvaged from other navy yards and stations. This furnace is also used for making experimental heats of steel with new alloys before making larger heats in the 6-ton and 30-ton furnaces. It is contemplated to install sometime in the future, a small motor-driven rolling mill for finishing tool steel.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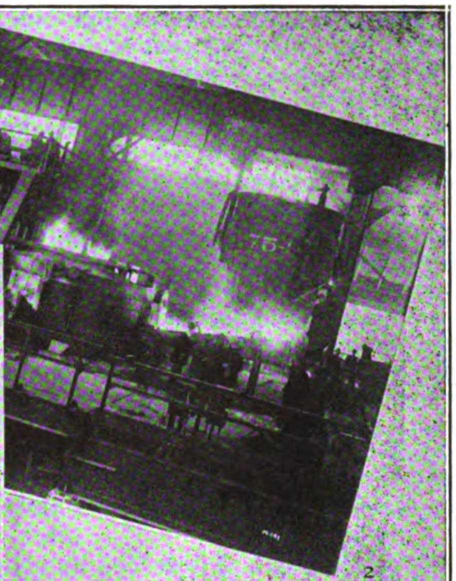
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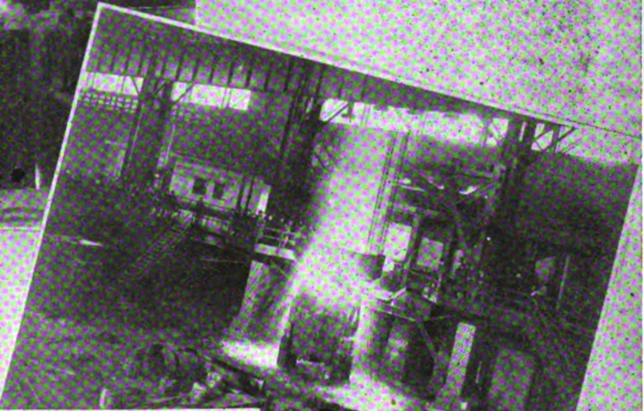
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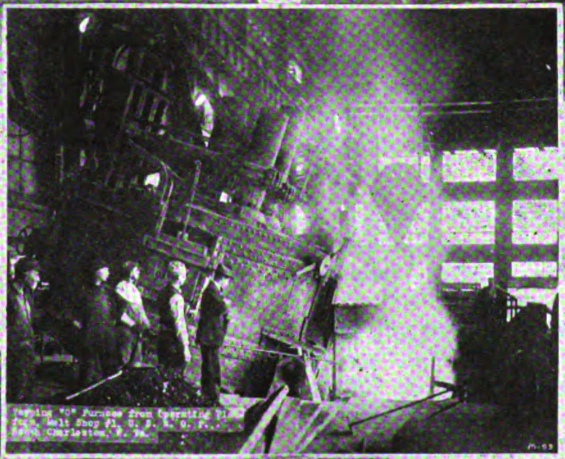
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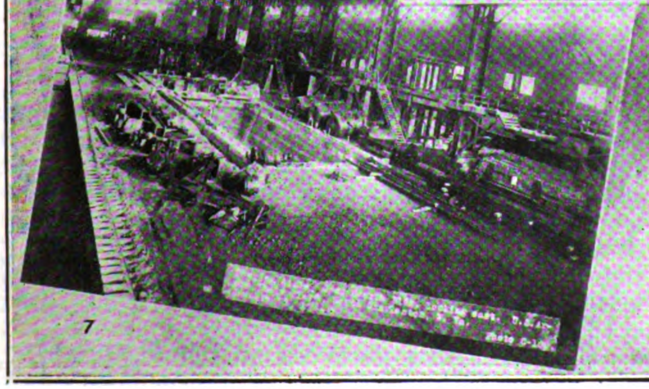
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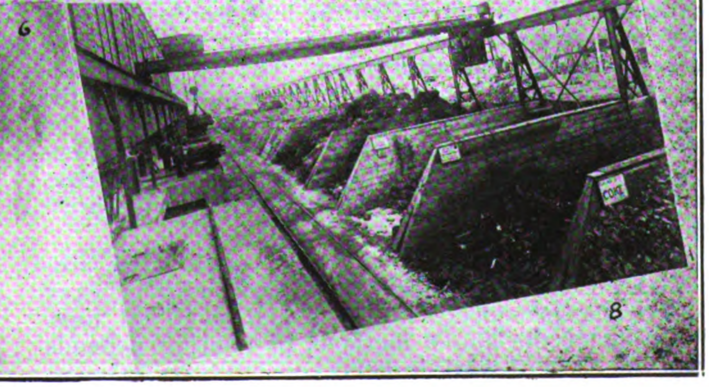
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Melt Shop No. 2.

Melt Shop No. 2 at the extreme south side of the South Unit, running east and west and parallel with the Chesapeake & Ohio Railroad tracks. It covers altogether 331 feet by 516 feet. It is made up lengthwise of twelve bays each 43 feet long. The pouring bay is 107 feet wide, the charging bay is 86 feet, the leanto 32 feet and the stockyard 106 feet wide. The charging floor is 17 feet above the ground of the pouring bay. The charging floor extends 30 feet, beyond the building line into the stockyard, thus forming an elevated charging platform. This contains two parallel tracks and track scales, so that if desired, charges may be made up directly from the stockyard scrap pile by means of electric magnet and 15-ton overhead traveling crane. The accompanying photograph, Fig. 4, shows charging bogies on tracks described above, in process of being loaded. harges may also be made upon the ground level and delivered to the charging floor over the scales by way of an inclined trestle at the east end of the platform.

Melt Shop No. 2 is served by six cranes, described by the table below:

Location	Pouring Side			Charging Side	Stock Yard	
Crane Number	1	2	3	4	5	6
Make	Morgan	Morgan	Morgan	Shaw	Shaw	Shaw
Type	2-gird. hook	4-gird. ladle	4-gird. ladle	2-gird. hook	2-gird. hook	2-gird. hook
Capacity— Main Host	250	125	75	25	15	15
Capacity— Auxiliary hoist ..	40	25	15	10	..	..
Speed per min. aux.	20	23	30	30	..	..
Speed per minute— Bridge	200	200	200	250	300	300
Speed per minute— Trolley	75	75	100	150	150	150
Speed-main hoist ..	10	10	14	23	50	50

At the present time, there are two 75-ton basic open-hearth furnaces, and two 40-ton basic electric melting furnaces in No. 2 Melt Shop. Pig iron and scrap are melted down in the open-hearth furnaces and transferred to the electric furnaces for refining and finishing. Provision is made for the addition of one more 75-ton open-hearth furnace west of the two now installed.

It is proposed to re-erect in the South Unit (Melt Shop No. 2), two of the 6-ton furnaces now located in Melt Shop No. 1. These small furnaces will be used for melting down cold nickel chrome scrap for projectiles and smaller ordnance forgings. This will concentrate the melting of all the high-grade ordnance steel into one building with minimum overhead expense and maximum supervision. The use of the electric furnace in melting steel of this kind results in the recovery of considerable chromium which would be lost by oxidation if the melting were done in an open-hearth furnace. The reducing atmosphere of the electric furnace enables practically all the chromium present to be recovered.

Steel for armor plate, large and small guns, projectiles, etc. is both bottom and top poured into heavy iron molds, provided with brick and sand hot tops. Variation of the above methods of pouring depends upon the class of work in hand.

It may be possible, after a long period of running, if so desired, to convert one of the basic open-hearth furnaces to an acid furnace, and cast the steel directly without duplexing, as the discard from the electric steel ingots is high-grade scrap—very low in both phosphorus and sulphur. Molten steel taken from the open-hearth for duplexing has shown phosphorus as low as .009 and sulphur as low as .015. On a heat of this kind made from electric furnace scrap, very little work has to be done in the electric furnace, except deoxidizing, making necessary addition of alloys and obtaining proper temperature before casting into ingots.

After duplexing through the electric furnace, ordnance steels are showing final analysis as low as .009 phosphorus and .006 sulphur. With this almost complete elimination of phosphorus and sulphur, in duplexing from the basic open-hearth through the basic electric furnace, it would be possible to use pig iron and scrap of much higher phosphorus and sulphur content than is ordinarily required for acid open-hearth and direct basic open-hearth practice.

In the design of the open-hearth furnaces by the naval ordnance plant, a study was made of dimensions and proportions of at least ten (10) successful operating furnaces. They were built under contract by William Swindell & Bros. of Pittsburgh. The portions of the open-hearth furnaces are as follows:

HEARTH—	
Length	36 ft.
Width..............................	14 ft.
Area in square feet................	504 ft.
Area in square feet per ton........	6.72 ft.
Height of roof above door sills...	7′ x 4″
REGENERATORS—Air only	
Length	25 ft.
Height............................	13 ft.
Width.............................	14 ft.
Checker volume....................	4550
Cubic feet per ton.................	60.7
Air uptake square inch............	2809
One stack on each furance........	6′ x 150′
HEARTH ROOF—	
Thickness..........................	12″
Skewback—above foreplate........	5′ 11″
Charging doors—center............	4′ 6″ x 4′ 6″
2 doors..........	3′ 6″ x 3′ 6″
2 doors..........	3′ 6″ x 3′
Spring (roof)......................	17″
Port Area..........................	34″ x 6′ 10½″

Blaw-Knox water-cooled doors, frames, buckstays and valves.

Cooling water consumption—25-pound pressure 150,000 gallons per 24 hours.

Natural gas consumption—about 1,000,000 cubic feet per day—btu in gas 950 to 1000.

The gas is fed on both sides of the ports through a 4-inch pipe under 8 to 12 ounce pressure.

The open-hearth furnaces are served by one standard 5-ton low type "Wellman-Seaver-Morgan" charging machine designed for handling 7-foot boxes. Principal dimensions of machine are as follows:

Span C. to C. track wheels.......................	24′ 6″
Wheel base of machine..........................	16′ 3″
Maximum stroke of ram..........................	19′ 0″
Maximum lift at end of ram.....................	2′ 6″
Speeds—under full load:	
Hoist...........................	18 to 20 strokes per min.
Twist of ram............................	20 to 25 R. P. M.
Cross travel of trolley...............	150 to 200 ft. per min.
Longitudinal travel of machine......	350 to 400 ft. per min.

Charging bogies carry four 5-ton boxes. Bogies have plate steel tops. Charging boxes are steel castings made at the naval ordnance plant. The hot metal ladles were designed at this plant and furnished on contract by the Treadwell Engineering Company. Ladles are 40-ton, 75-ton, and 100-ton capacity, provided with adjustable yoke type stopper rigging. A side dump cinder car of 200 cubic feet capacity is used for handling slag as it overflows from the ladle.

A large pouring pit 30 feet wide and 150 feet long was built for teeming large ingots. A portion of the pit is 16 feet deep, the balance 8 feet. This also serves for burying and slowly cooling ingots in ashes.

At the east of the building, in line with the charging floor, are ten large bins built for storage of raw materials, under cover of the main roof of the building. Material from these bins is lifted by means of a single line grab bucket—hung on the overhead traveling crane and placed wherever desired without double handling. Each open-hearth furnace has five doors electrically operated from a central station by "Shepherd" hoists of 2 tons capacity. The tapping spouts are steel castings and are handled by means of 5-ton Jib cranes 25 feet effective radius, attached to the building columns in front of the furnace.

A well equipped "quick test laboratory" is located midway between the open-hearth and electric furnaces. A storeroom containing miscellaneous supplies likely to be needed in case of emergency, has been located at one end of the building on the charging floor. Office for foreman and clerks is also located on the charging floor close to electric furnaces where the steel is finished. Well equipped lavatories, showers, and locker room are provided for the workmen.

40-Ton Electric Furnaces.

Two 40-ton electric furnaces are located well out in the pouring bay, east of the open-hearth furnaces. A spacious platform has been provided around the furnaces on the same level as the charging floor of the open-hearths. The electric furnaces are four-door Heroult type, basic lined, and may be briefly described as follows:

Diameter of steel shell unlined........	18 ft.
Height of steel shell unlined..........	8 ft.
Thickness of brick walls..............	18" with 1½" sand between brick and furnace shell.

They operate on a 3-phase, 60-cycle circuit, at 90, and 110 volts. Power is received through a 3300 kva water-cooled transformer, from a 6600 volt primary circuit. Each transformer is located on the charging floor directly behind the furnace, which it supplies with power. At the present time, 24-inch amorphous carbon electrodes are being used. These are operated by "G. E." regulators, equipped with 5 hp motors for raising and lowering. Provision is also being made for the use of 14-inch graphitic electrodes.

In tilting, the furnace rolls on eight (8) large spools instead of tilting about trunnions as in the case of smaller furnaces of the same make. A circular base casting on the furnace rests upon the eight large steel spools and is rocked by means of a large driving gear operated by a 35 hp, 230 volt tilting motor with brake. These are the largest electric furnaces built to date. The furnaces are equipped with water-cooled doors, frames, skewback, electrode holders, roof rings and current conducting electrode arms. After much thought, the furnaces were placed so that both would tap in the same direction into the pouring bay instead of towards each other. Large tilting platforms were placed in front of each furnace. These are in one piece and open away from each other so as not to obstruct the view of the craneman or operator on the melting floor during tapping. The platforms are operated by electric motors and a series of drums and cable.

With the equipment provided, it is possible to make individual ingots up to 175 tons in weight. This is the maximum weight required for present day armor plate or gun forgings. In the development of high-grade alloy steels, containing manganese, silicon, chromium, molybdenum, zirconium, vandium, tungsten, titanium, and other rare metals, the electric melting furnace has enabled steel-makers to accomplish much which could not be done in either the acid or basic open-hearth furnace. Besides eliminating to almost a trace objectionable elements like phosphorus and sulphur, the electric furnace with its reducing atmosphere enables the rarer elements mentioned above to be alloyed with the iron in the furnace, and not left to the uncertainty and non-uniformity resulting from adding them in the ladle.

Furthermore, chemical composition, and temperature control may be more carefully regulated in the electric furnace than in the open-hearth. Electric steel may be more nearly de-oxidized before leaving the furnace by proper working of the bath and slag, than can be accomplished by the addition of the most vigorous deoxidizers. Too liberal use of deoxidizers like manganese, silicon, or aluminum, or titanium, in the ladle or mold, are very apt to fill the steel with non-metallic inclusions which injure its use for ordnance purposes.

It is in this respect as was stated in the beginning of this article, that the electric furnace with its greater flexibility of operation seems to offer a more positive means of procuring the necessary higher grade of steel for armor plate, large guns, and projectiles, than could be obtained in the open-hearth furnace. The uniformity and lower rejections of forgings due to "off composition," slag and other impurities, more than offsets the increased cost of the electric steel ingots.

ENGINEERS IN PUBLIC LIFE.

The American Engineering Council of the Federated American Engineering Societies has sent to President Harding a communication asking that an engineer be appointed Assistant Secretary of War. Another communication requested Mr. Harding to name an engineer for the vacancy on the Interstate Commerce Commission.

The appeal to President Harding to select an engineer as Assistant Secretary of War states that this position is one requiring "very special qualifications a large part of which are concerned with engineering."

In requesting the President "to give earnest thought to the selection for the Interstate Commerce Commission of a man whom to his other qualifications adds the training and experience of an engineer familiar with transportation problems," the communication sent by Chairman Channing, says:

"The transportation systems of our country are largely the creations of its professional engineers. This statement can be made without disparagement to the statesmen, the mechanics, the laborers and many others who, with the engineers, have contributed to the development of transportation."

Scullin Steel Company's New Mills

New Features Not Common to Rolling Mills Are Used in the New Scullin Steel Company Installations at St. Louis.

By F. B. MENNER,
Manager, Mill Department.

AMONG the new steel mills put into operation during the past year, that of Scullin Steel Company, St. Louis, Mo., modern in all its facilities, presents some new and interesting features heretofore not common in rolling mills.

The mills were installed adjacent to the Company's large open-hearth foundry plant, and designed to take care of two-thirds of the tonnage from their twelve 35-ton, basic open-hearth furnaces; the remainder, or some 6,000 tons being used for steel castings of which the Scullin Company is one of, if not the largest producer in the country, having devoted over twenty years to manufacturing railroad specialties, castings for sugar mill and mining machinery, and similar work.

The installation is designed to economically produce wide range of billets, merchant bar and structural shapes which the central and southwestern markets demand, and up to the high standard that has been established as Scullin quality. The mills in operation at present consist of a 4-stand, 3-high, 22-inch mechanical mill, and a 12-inch Belgian mill of 5 stands, preceded by a 16-inch mill for roughing. Plans are under way for an 8-inch mill to take care of the small sections economically produced in hand mills. All standard sizes are being rolled. Rounds and squares up to 6-inch, flats to 7-inch wide, angles to 6 x 6-inch, and beams and channels to 8 x 10-inch, in addition to a number of specials which the Scullin Company have developed.

The steel is transferred from the open-hearth by the Company's interplant railroad, in the form of 12 x 12-inch, 10 x 10-inch and 8 x 8-inch ingots, which are charged cold into an oil fired continuous heating furnace. This furnace was constructed by the Scullin organization, all patterns and castings being made in their foundry department. It is of the flat arch, water-cooled type, the hearth being 15 feet x 46 feet 3 inches. The ingots are transferred from cars by cranes, to a skid table from which they are delivered by roller line to an electrically operated, rack and pinion ingot charger, which pushes them through the furnace in double rows on water-cooled skid pipes. Preheated air for the eight Anthony oil burners used, is supplied from tempering chambers built in the roof of the structure. Furnace capacity is between 25 and 30, 12 by 12-inch ingots an hour, or approximately 27 tons.

The fuel oil is pumped from the Company's large storage in the foundry department, two-third of a mile away, to a 20,000 gallon concrete secondary tank adjacent to the mill buildings, from which two motor-driven triplex Gould pumps circulate the oil, the consumption being checked by means of oil meters at each furnace.

The furnace has an end discharge and delivers ingots to a table which is provided with hydraulic ingot turner to handle tapered ingots.

22-Inch Mill.

The 22-inch mill has four stands of three-high rolls, with enclosed pinion housings. The first, or what would ordinarily be a roughing stand is unusual in that it is identical with a three-high blooming mill in its operation. The center roll is, however, balanced and operated up and down by hydraulic cylinders, the top roll being raised and lowered by motor-driven screwdown. The rolls are turned with one bull head and five box passes, giving a range of popular size billets from 3 to 8 inches. During roll changes, and such other time as is required, ingots are rolled into billets for use in the small mills and outside shipment. Since only 15 minutes are required to uncouple the remaining three stands, this combination mill is made a constant tonnage producer and a unit most satisfactory from a mechanical and economical standpoint.

Two, 30-inch hydraulic up-cut shears are located on runout tables on the up-and-down side of the blooming stand, for end cropping and billet shearing. These together with a motor-driven shear gage, hydraulic pusher, and an electrically operated billet conveyor, delivering billets to the central storage yard, comprise the billet handling equipment.

For the main mill drive, an 1800 hp induction motor, operating on 2200 volts, has been provided by Westinghouse Company. Its speed of 366 rpm is reduced to mill speed of 68.6 rpm, by double helical gear set; on the pinion shaft are overhung two 9-inch cast steel fly wheels, weighing 27,000 pounds each.

Four traveling and tilting tables deliver the material to the passes of the various stands with the aid of pull-overs on the transfers, back and front of the mill. Each table is operated by Westinghouse motors of 80, 60 and 30 hp respectively.

A sliding frame hot saw is provided on the finishing stand runout table.

One hot bed, 65 feet long, and equipped with upenders, pullover channels and dogs, has been installed at the present time, with provision for a second after mill tonnage is built up.

The finishing end has a motor-driven roller straightener for structural shapes, which is pulled in and out of position with the hot bed delivery and shear approach table transfer as is required. Two motor-driven vertical shears are served by roller tables and transfers, and sheared material is dumped into the cradles ready for inspection, weighing and shipping.

The shipping facilities include a 20-ton Fairbanks scale and trackage in the building for five standard cars.

A 15-ton crane has been provided for handling finished material and a five motor, 45-ton crane of sufficient capacity to transfer the complete housing with its roll and guide equipment, to save time in roll changing.

Roller tables, hot bed and other mill auxiliaries are driven by Westinghouse mill type motors, of which over 100 have been furnished. These are operated by master switches and magnetic control panels, installed on five operating stations along the sides of the building, thus permitting the operation of the mill to its full tonnage with a very small force of men.

12-Inch Mill.

Billets for the 12-inch mill, of 3 x 3-inch and 4 x 4-inch sizes are handled from stock piles by one of the two 5-ton electric cranes in the storage yard, weighed and transferred to billet platform for the 12-inch mill furnace, from which they are fed in pairs on a motor-driven roller chain conveyor to a pusher at the charging end. Stops are provided for charging one, two and three rows for economy in heating. The furnace pusher is a duplicate of the one installed at the 22-inch mill furnace, and the furnace for the small mill is identical in design with the one described above, but with reduced dimensions; the hearth being 9 x 37 feet. Four burners are used and the billets are pushed through on seven skid pipes.

The five stand, 12-inch mill, with its one stand of 16-inch roughing rolls, is a typical Belgian mill installation. A motor-driven vertical shear for cutting long billets to be rolled into smaller sections has been installed on a roller line between the two mills, and a spacious iron plate floor on both sides of the mill provides ample room for running out bars during rolling.

A mechanical hot bed of the ratchet and shuffle bar type handles all material from the 12-inch mill. This is one of the first of its kind built by the United Engineering & Foundry Co., who built the mills and furnished most of the other mill equipment. The bed will handle bars up to 110 feet in length, discharging automatically in numbers as required, to the shear delivery table.

The finishing end of the 12-inch mill is similar in its equipment to that provided in the larger mill. A roller straightener, gag presses, cold saws, etc., considerable storage or inspection space, shipping trackage, and two 10-ton cranes are included in the facilities.

Roll Shop.

A roll shop has been provided adjacent to the 12-mill building with three motor-driven roll lathes of 34, 26 and 18-inch swing respectively, all with double beds, having a capacity for turning six rolls at once. Here also are installed a number of machine tools for making quick mill repairs. The shop is 35 x 100 feet, well-lighted with side wall sash and skylights. It is served by a 5-ton crane, a small transfer track being used for delivering rolls to both mill buildings. The entire complement of rolls used in the mills have been designed and turned here. All steel rolls, together with mill pinions have been made in the Scullin foundry, and an unusual record of high tonnage and no roll breakage speaks for the success of the Company's premier efforts in this line of work.

Water System.

The high pressure water system, from which are operated the blooming mill roll balance, up-cut shears, ingot turner, etc., consists of two 300 gallon per minute, Aldrich triplex pumps which are direct driven, each by a 150 hp General Electric motor. The accumulator which is of fixed cylinder type was manufactured by the same Pump Company. It is counter-weighted with concrete blocks to maintain the 550 pound per square inch pressure.

The water for the low pressure system, which feeds the mill rolls and furnace skid pipes, in addition to other equipment which requires cooling, is handled by two 2,000 gpm Dayton-Dowd pumps, each direct connected to a 75 hp General Electric motor; one pumping from a cold well and distributing through an 8-inch line the cooling water to the skids and mills; the other, from the well to which the hot water is drained, through a 10-inch line, to the spray header mounted in a valley formed by the roofs of two of the mill buildings. Here branches with some 50 impact spray nozzles effect the cooling of the water, which drains bac kover the 150 feet false roof to the cold well.

Sub-Station.

Power for all plant operations is purchased from the Union Electric Light & Power Co., untransformed at 13,200 volts. A brick and concrete sub-station, 50 x 54 feet, houses the six Westinghouse, 1000 kva transformers and 500 kw rotary converter, distributing 2200 and 220 volts alternating current, and 230 volts direct current to main drive and mill auxiliaries.

The switchboard of 14 panels was furnished by the General Electric Company. All main feeder and transformer oil switches are solenoid operated. Every precaution has been taken for safety and fire prevention, all cell work being of concrete, while the feeder lines and busses are thoroughly protected by concrete insulating walls.

Service Building.

A service building of concrete and brick construction, 50 x 80 feet, houses the store-room, hospital, and mill offices, parts of two floors being used as wash and locker rooms for mill hands. Great care has been taken to insure cleanliness in the building and to provide for the comfort of the men. The showers, lavatories and toilet facilities are of the most improved and sanitary types. Each workman is provided with two lockers for street and working clothes.

A first aid attendant is always on duty to care for minor injuries in the first aid room, while other welfare work throughout the plant has been given careful attention. Guards, hand rails, etc., have been installed and belts substituted by direct motor drive to add to safety of employees and eliminate possible hazard.

The two main buildings are of typical mill type construction but unusually well lighted and ventilated by mechanically operated Fenestra continuous sash in all sidewalls and monitors. Both are approximately 76 x 500 feet. The billet storage yard and furnace charging shelter occupy a 60 x 500 feet space between them.

All machinery was erected and pipe and electrical work installed by the mill organization. The buildings and foundations were constructed by Fruin-Colnon Contracting Company of St. Louis. The engineering and construction work was in charge of Frederic B. Menner, manager of this department of the Scullin Steel Company, and Perin & Marshall Co. of New York, acting as consulting engineers. George H. Raab is superintendent of the mills.

Mill Table Equipment That Reduces Cost

Recent Tendencies to Lower Selling Prices Make Necessary Some Thought Toward Reducing Operating Costs in Every Manner—Flexible Roller Bearings Assure a Decrease in Cost Per Ton.

By J. M. KELLY, Engineer,
Hyatt Roller Bearing Company.

TO be "right up to the minute" in mill construction and design has many advantages as well as the few disadvantages that have been pointed out in these columns from time to time. The modern construction naturally costs more than the older types of mills but more tonnage at less cost per ton can be produced on the modern mill taking into consideration that sufficient tonnage of but a few standard sizes, lengths, etc. can be booked thus keeping the mill operating with few of the costly delays that are inevitable when small tonnages necessitate several roll changes.

The modern equipment contains all that is essential to keep down the cost per ton of the finished product. In a pronounced majority of the recent modern mill table installations, engineers have given special attention to the question of table roller bearings. It has always been the desire to design tables that will function properly with little upkeep to the vital parts. Bearings and gears on table rollers and line shafts cause considerable trouble and frequent delays and replacements of an inferior piece of the equipment add an appreciable item to the cost per ton of the product. In the modern mill installations these items of upkeep and maintenance, although not entirely eliminated, have been reduced to a minimum by the use of flexible roller bearings.

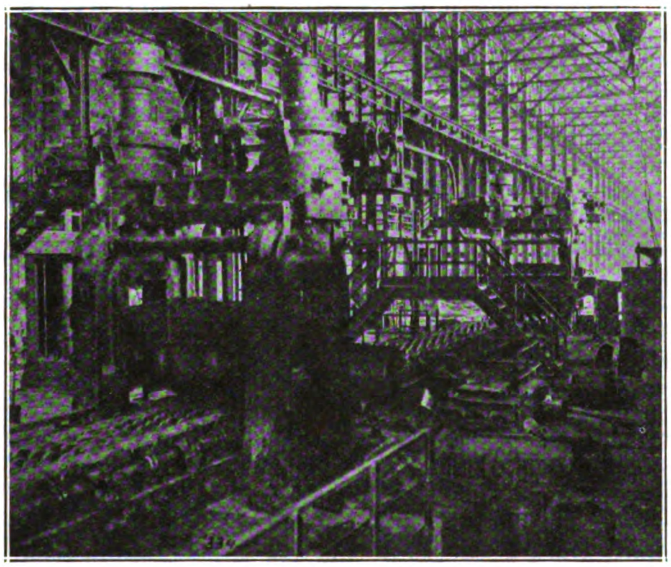

Fig. 1—84-inch Tandem 3-High Plate Mill, Brier Hill Steel Company, Youngstown, Ohio. All tables equipped with Hyatt Roller Bearings.

Plate mill tilting tables, especially those tables where the plate being rolled extends out beyond the bearings, must have real bearings capable to withstand the severe temperatures and the knocks and abuse that are incident to such equipment. Several plate mills have been built within the past four years with flexible roller bearings on the tilting tables. Other plants have found it necessary to rebuild tables and in such instances have incorporated the flexible roller bearing. In adopting such equipment that seemingly is radical from previous practice, progress in mill table design has been satisfied. But this satisfaction of progress is insufficient. A substantial return on the investment is required. This return has been realized by cutting out delays and upkeep, thus reducing cost per ton of steel. Added advantages assist toward the reduction in cost.

It is natural to assume a reduction in power consumption when an anti-friction bearing of the flexible roller type is incorporated. The first comparative test, made in 1916, between flexible roller bearing equipped tables and plain bearing equipped tables was conducted at one of the large Youngstown plants. A small section of table on a billet mill was found to consume 15 hp with the plain type bearings. The flexible roller bearing was substituted and, after two and one-half years of service, a power reading was taken. The flexible roller bearing equipped table required only 52 per cent of the power that had been required to drive the same number of plain bearing equipped table rollers. Had the line shaft bearings been equipped in the same manner only 40 per cent of the plain bearing power would have been required, thus effecting a saving of 60 per cent in power consumption.

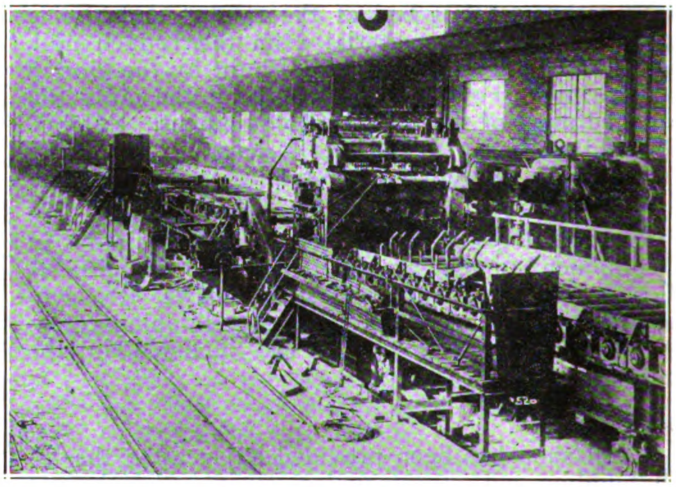

Fig. 2—35-inch—3-High Blooming Mill, John A. Roebling' Sons Company, Trenton, N. J. All tables equipped with Hyatt Roller Bearings.

During the entire two and one-half years of service there had been no replacements of flexible roller bearings. Gears, journals and bearings proved to be in perfect condition. In fact, the original grinding marks could be distinguished on the roller bearings, no wear

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being perceptible.

No attention had been required other than an occasional lubrication. The roller bearing journal boxes had been properly designed to retain lubricant without excessive leakage that generally accompanies the common type of bearing. Cleanliness and no danger from fires was in evidence.

Plants which have had experience with both types of bearing installations on mill table equipment have given various figures as to what has been accomplished in the way of savings. One plant where an 84-inch plate mill operates reports a decrease of 60 per cent in power consumption and 70 per cent in upkeep and maintenance, since the flexible roller bearing has been in use. Another plate mill that operated with common bearings on the tilting tables found it necessary to spend $500 per month for bearing upkeep and maintenance on gears, the latter depending on proper bearing alignment.

When flexible roller bearings were installed on new tilting tables for this mill, total upkeep was reduced 75 per cent, during the year that the new tables have been operating.

A modern combination structural and bar mill was designed for a plant in the South. The ring-oiled bearings, originally designed for the tables, were higher by $6.00 per bearing than the flexible roller bearings that were incorporated into the tables when finally built. The reduction in first cost of this installation made possible a smaller overhead. During the past two years of operation, upkeep has been negligible. Gears are maintained in their proper positions. There is no chance for the gears on table rollers to sag and get out of mesh with the line shaft gears. The flexible roller bearings are operating day in and day out without causing the wear that would allow gears to get out of alignment, as would have been the case with ordinary bearings.

The recent tendencies to lower selling prices make necessary some thought toward reducing operating costs in every conceivable manner. There is no better method to assist in attaining decreased cost per ton than by investing in table bearings that decrease maintenance, decrease power consumption, and operate efficiently under the adverse conditions that are incident to steel mill practice.

On mill table equipment, the flexible roller bearing assures a decrease in cost per ton of the finished product. Engineers and operating men are insistent on such bearings since actual operating experience on tables of bar, billet, plate, band, strip and blooming mills has developed:

1. Power consumption reduced 50 per cent minimum.
2. Less wear on bearings, journals, gears.
3. Minimum replacements.
4. Less lubricant consumption.
5. Less attention.
6. Cleanliness and no danger from fires.
7. Simplicity of design.
8. Fool proof installation.

Electric Furnaces for Making Steel

Classification of Electric Steel Making Furnaces—General Features and Advantages of the Arc Furnace and the Resistance Furnace—Operating Features of Electric Furnaces.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART II.

THIS furnace was invented by Ivar Rennerfelt of Stockholm about the year 1912 and was first employed on a small scale for melting steel in small foundries at Halstahammar and other places in Sweden. The furnace, like Stassano's, is heated by an independent arc, but the electrical supply is so arranged that the arc blows downwards and thus heats the contents of the furnace more directly.

The Rennerfelt furnace has three electrodes A. B, and C, Fig. 7, which are supplied with two-phase current; the vertical electrode, C, serving as a common return for the two phases. An electric arc is formed between the tips of the three electrodes, and the magnetic force that is exerted by the current flowing in the vertical electrode, forces the electric arc downward. The action of the arc is shown more clearly by stopping the current supply of one electrode, so that there remain only two electrodes, B and C, carrying single-phase current. When this has been done it will be found that the arc blows out in a direction bisecting the angle between the electrodes.

This action of the arc can be understood from Fig. 8, in which A-B and C-D are the two electrodes in which the current is flowing in the direction A-B C-D, as shown by the arrows. As a conductor carrying a current is surounded by circular lines of force, it follows that at B-C, owing to the crowding of these lines inside the angle, there will be a resultant magnetic field perpendicular to the plane of the figure. In consequence of this the electric arc B-C, being a movable conductor, will be made to move in the direction E-F.

If the electric current had been supplied only to electrodes A and C in Fig. 8, the arc would have been directed downwards and to the right, and when current is supplied to the three electrodes the arc moves straight down, this being the resultant direction of the flames that would be produced by the two single-phase currents.

An early form of the furnace Fig. 9 had other novel features in addition to the arrangement of the electrodes. The furnace was constructed in a horizontal cylindrical drum, mounted on trunnions through which passed the lateral electrodes, and the lining of magnesite brick was circular, as shown in the figure, so that the roof, walls and hearth were all parts of a circular lining. A hearth-lining of magnesite was laid over the brick-work of the lower half of the furnace. Only one door was provided for a

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furnace of moderate size, and this served for charging, for repairs to the furnace and for pouring the melted steel. A circular lining within a steel shell would seem to be a very strong form of construction and permits the use of magnesite brick for the roof instead of the more common silicia brick. A lining of asbestos is placed between the shell and the brick-work, in order to retain the heat and to allow the bricks to expand. The electrodes enter through air-tight holders and, as there is only one door, it should be easy to prevent the entrance of air into the furnace, and thus to save electrode-consumption, oxidation of the steel and loss of heat.

The circular construction of the furnace does not permit of easy repairs or replacement of the roof of the furnace, and in later forms this special feature has been given up and the furnace is made circular in plan and has an arched roof that can easily be replaced. This change may have been brought about in part also on account of the extreme difficulty, during the war, of obtaining magnesite bricks, and the consequent necessity of using acid linings.

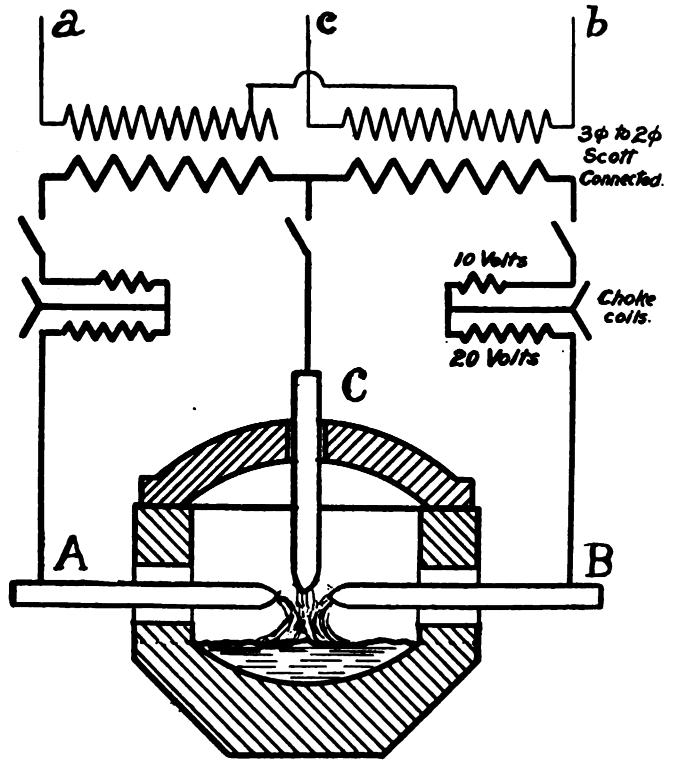

Fig. 7—Rennerfelt Furnace.

Another improvement is the arrangement for altering the inclination of the lateral electrodes. In the earlier furnaces these were horizontal or slightly inclined downwards but were incapable of vertical adjustment. The present arrangement allows of the electrodes being raised to accommodate a full charge of scrap, and as the charge melts down the electrodes can be lowered to keep the arc close to the metal. By this means the arc is kept within 3 inches of the bath during the whole operation, and the flame of the arc spreads out into a circular patch on the slag of 8 or 10 inches diameter, while at times the flame appears to cover the whole bath.

When the charge is completely melted the electrodes can be lowered until the arc passes from each electrode to the slag and metal, so that the furnace has the advantage of direct-arc heating during the refining period.

Referring again to Fig. 7, it will be seen that the wires, A, B and C, carrying high voltage three-phase current, are led to two transformers having the Scott connection, and from these, low-voltage two-phase current is supplied to the furnace by means of three cables. With this arrangement, the middle electrode, which serves as the common return for the other two, carries 52 times the current in each of the lateral electrodes, or 40 per cent more than each lateral electrode is therefore made proportionately larger.

The Rennerfelt furnace, like the Stassano furnace, having an independent arc, is able to use current at a higher voltage than is usually found desirable in direct-heating arc furnaces, and this, in spite of the fact that only one arc is produced, while in the Heroult furnace there are two arcs in series. Any increase in voltage results in economy in transformers, bus bars and cables as well as in electrodes and electrode holders; it also reduces the electrical and thermal losses in the electrode and thus raises the electrode-efficiency. As a rule the voltage of each phase is about 100 (or 140 volts between the two lateral electrodes) but 110 or 120 volt supplies have recently been employed and this can be lowered to about 60 volts per phase for use during the refining period, when the arc is playing between electrode and charge and when a smaller rate of heating is desirable.

When the charge has melted and the furnace is fully heated, the 100-volt two-phase arc is very steady and affords a satisfactory load for the power-supply, but when the furnace has been freshly charged with cold scrap, there is some difficulty in keeping a steady arc with the full voltage. The earlier furnaces were provided with rheostats in series with the lateral electrodes for the purpose of steadying the arc at this period, and this caused a serious loss of power, but at present reactance coils, marked "choke coils" in the figure, are used for the same purpose and are cut out by switches as soon as they can be dispensed with. A recent tendency, in this as in some other furnaces, has been to provide a larger amount of power for a furnace of a given capacity; thus from 200 kw to 300 kw per ton of furnace capacity is now provided, instead of from 100 too 200 kw as in the past, and this change, besides lowering the melting-cost, increases the steadiness of the electrical load. Thus, in a three-ton furnace, which is drawing 600 kw the load will decrease steadily, owing to the burning of the electrodes, until after 5 minutes, it will have dropped to 550 kw if no regulation of the electrodes has been made meanwhile.

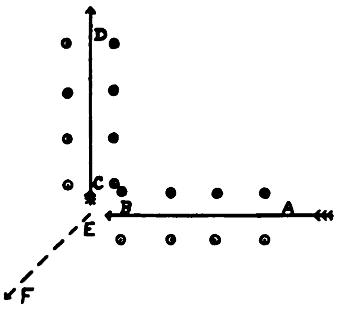

Fig. 8—Action of Arc in Rennerfelt Furnace.

The electrodes are of Acheson graphite and are provided with threaded joints for connecting additional lengths, so that there is no loss by wasted stub-ends. Graphite electrodes, on account of their smaller cross-section, are particularly desirable in furnaces of this type, especially when it is desired to adjust the electrodes to different angles. The vertical electrode might be made of carbon, but even here the graphite electrode has the advantage of needing a smaller opening in the arch. The regulation of the electrodes is usually by hand, which is practicable with this furnace, as a high-voltage arc, when working steadily, needs less frequent regulation than a short low-voltage arc. The middle electrode is always regulated by hand, being moved downwards from time to time, so that its end is between the ends of the other electrodes, but in some recent furnaces automatic regulation has been applied to the lateral electrodes.

The width of the Rennerfelt furnace is limited by the length of the lateral electrodes, which must reach to the middle electrode for striking the arc. The furnace, is 42 inches in diameter, inside the lining and 6 feet in diameter inside the shell, and has a capacity of 1500 pounds. This requires a length of unsupported electrode of about 30 inches. For furnaces of more than about 7 feet internal diameter and 6 tons capacity, the circular form would probably be given up, the furnace being built oval in plan and being provided with two or more sets of electrodes. The construction of a large furnace, with multiple electrodes, will be seen by reference to Fig. 11, which represents a 40-ton furnace. The design shown, however, is of the older cylindrical type, and this would probably be modified in view of later experience so as to permit of ready replacement of the roof.

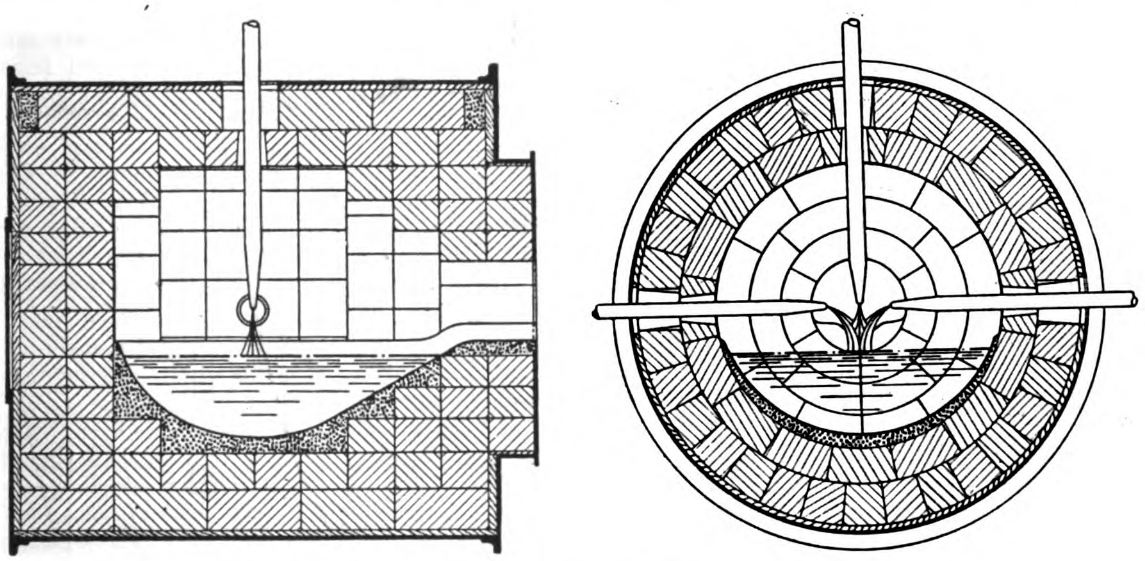

Fig. 9—Early Form of Rennerfelt Furnace.

Up to the present Rennerfelt furnaces have been of small and moderate sizes, the largest having a capacity of 3 or 4 gross tons and a power of 800 or 900 kva. They have been used in general for melting steel scrap, and for this purpose they seem to compare favorably with furnaces of the same size of the direct-heating arc types, while they have additional advantages as regards steadiness of load during the melting period. A steel foundry making small steel castings with an acid-lined furnace, which is only operated during the daytime, gives the following results as typical of a days' run:

Heat No.	Charge pounds	Time hours	Kw hours
79	1900	4.0	800
80	1800	3.7	520
81	1825	3.4	520
82	1800	3.0	490
—	—	—	—
Total	7325	14.1	2330
Average	1831	3.5	637 Per net ton.

The electrode consumption was from 8 to 11 lbs. per ton.

Basic lined furnaces of 300 kw for a ton capacity, and taking off one slag, have been operated continuously with 670 kw-hours per ton, finishing the heat in 2½ hours. The electrode consumption is said to be under 6 pounds per ton of steel, in continuous operation, and the refractory costs are also moderate; silica roofs lasting in several instances for at least 250 heats, and silica side-walls over 300 heats.

The American makers, Messrs. Hamilton and Hansell of New York, give the following rating of their furnaces:

Type	Capacity (Steel)	Transformer rating (40° C. normal rise)
O. special	100-200 pounds	40- 60 Kva.
O.	300-500 "	80- 100 "
1-A.	1000 "	150- 200 "
11-B.	1 gross ton.	350- 400 "
IV.	3 to 4 gross tons	800-1000 "
V-A.	5 to 6 gross tons	1200 "

The makers give the following estimate of the cost of 1 ton (2,000 pounds) of molten steel. The figures refer to the continuous operation of a 1-ton furnace:

Labor, 2 shifts of two men each	$ 2.12
Scrap, 1900 pounds at $30.00 a ton	28.50
Pig-iron, 100 pounds	1.75
Ferro-manganese, 15 pounds	1.72
Ferro-silicon, 8 pounds	.64
Melting loss, 2 per cent	.60
Iron Ore	.10
Aluminum, coke and fluors par	.25
Power, 700 kw hours at 1 cent	7.00
Electrodes, 8 pounds at 22 cents per pound	1.76
Refractories	.95

Maintenance and repairs	1.70
Water, tools and incidentals	.15
Interest and depreciation	2.00
Total cost of 1 ton of steel in ladle	——$49.24

If we take away the cost of the pig and scrap, which vary continually, but leave in the melting loss and all other items, we obtain the figure of $19.00 as the conversion cost of one ton of molten steel.

This estimate was supplied during 1918 and should represent war conditions, but the charge for labor will probably be higher in most places at the present time. If we assume that ten heats of one ton each are poured per day, the rate of wages on the above estimate work out to 44 cents an hour, and this does not allow for interruptions. Power can be obtained in many places at less than 1 cent per kw-hour, but this figure will provide for irregular use of the furnace.

In addition to their use for steel castings, Rennerfelt furnaces have been employed for making tool-steel and special alloy steels, for melting ferro-manganese and for iron foundry work. They have also found extensive use in melting copper alloys, bronze, cupro-nickel, etc., for which they are well suited, as the independent arc will cause less loss by volatilization than the direct-heating arc of most electric furnaces.

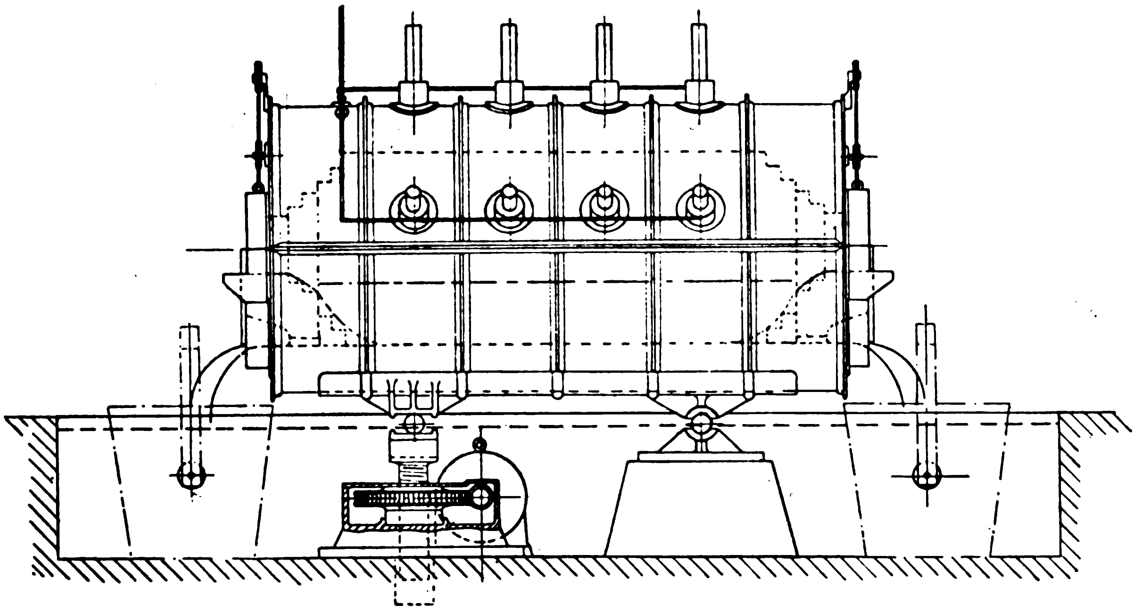

Fig. 11—Rennerfelt Furnace with Multiple Arc.

There are now more than 150 Rennerfelt furnaces in operation and under construction throughout the world for steel-melting and other uses. They vary in capacity from a few hundred pounds up to three or four tons, a large number being of about one ton capacity. Furnaces may in time, be built of large capacity, on the multiple arc system, for refining molten steel, but for this purpose the Rennerfelt furnace does not seem to offer any great advantage as compared with other types of furnace.

The following figures are given by the makers, as the power-consumption for melting various materials in small furnaces of the Rennerfelt type 5, in kw-hours per metric ton:

Power Consumption for Melting Per Metric Ton.

Red brass	168	kw.-hrs.
Pure copper	197	“
White iron	290	“
Gray iron	325	“
Ferro-manganese, 80 per cent	441	“
Steel scrap, not ready to pour	455	“
Steel scrap, melting and "killing" on an acid bottom, about	600	“
Steel scrap, melting and refining on a basic bottom, about	700	“
Ferro-manganese, 80 per cent, melting, holding, tapping and charging	741	“
Making 67 per cent ferro-tungsten on small scale	5730	“

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2. "The use of liquid ferro-manganese in the steel furnace." Axel Sahlin, Iron and Steel Inst., 1914 II. page 213.
3. "Electrothermic smelting of iron ores in Sweden." Alfred Stansfield, Dept. of Mines, Ottawa, 1915, page 51.
4. A discussion by G. Muntz and Ivar Rennerfelt of the use of electric furnaces in the steel-foundry.
   Met. and Chem. Eng., June, 1914, vol. XII, page 379.
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5. "The Rennerfelt Arc Furnace," C. H. Vom Baur.
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6. Electric Furnace for independent and direct-heating arcs, patent, C. W. H. Eckermann and I. Rennerfelt.
   Met. and Chem. Eng., January, 1917, vol. XVI, page 53.
7. "Rennerfelt electric furnace operation," C. H. Vom Baur, Amer. Electrochem. Soc. 1917, vol. XXXI, page 87. Met. and Chem. Eng., May, 1917, page 580.
8. "The Rennerfelt Electric Arc Furnace," 1919. Messrs. Hamilton & Hansell, Inc., 17 Battery Place, New York.

Editor's Note—The June issue of The Blast Furnace and Steel Plant will contain several special features. In addition to the report of the American Iron and Steel Institute, a special Power Department will be included. The feature of this will be a complete write-up of the most modern steam power plant in the steel industry.

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Heating Furnaces and Annealing Furnaces

Requirements Which Sheet and Pair Furnaces Must Meet—Comparison of Different Types of Sheet Furnaces.

By W. TRINKS.

PART XXVIII.

IN continuing the critical discussion and comparison of different types of furnaces, let us turn our attention to the furnaces which are used in the manufacture of steel sheets and of tin plates. It will be remembered that steel sheets and tin plates are rolled from sheet (or tin plate) bars of about 8-inch width, and of length equal to the width of the sheets which are to be rolled. The thickness of the bars varies from ¼-inch to 1½-inch, depending upon the length and thickness of the sheets which are to be produced from the bars. The sheet bars as well as the sheets themselves are exposed to the air for a long time during the rolling process and would scale excessively if the temperature were high. In consequence, sheets are rolled just above the critical temperature, that is to say at about 1400 degrees F., while sheet bars are rolled 100 to 150 degrees F. hotter. The low rolling temperature results in tremendously high forces between sheets and rolls, reaching 50,000 pounds per inch of width of sheet. At that high pressure any scale which might be formed is rolled into the sheets and mars the rolls. Furthermore, the sheets, which are rolled in packs, will stick together, if pure metallic red hot surfaces come together.

The furnaces in which sheet bars and sheets are heated must, in accordance with these peculiarities of manufacture, meet the following requirements:

1) Furnaces must suit the mill layout and the method of rolling.
2) The sheets must not oxydize in an irregular manner. No loose scale must be formed.
3) The sheets must be free from ashes or soot.
4) The sheets at different sides of the pack must have the same temperature.
5) A thin, uniform, firmly adhering layer of oxyde must be formed of such a nature that it stretches with the sheets in the rolls without cracking.

The old Welshmen who brought the knowledge of the art of rolling sheets to the United States appear to have been well acquainted with these requirements. In any event, the equipment which they had made possible the rolling of very good sheets. Improvements have been made from time to time; however, some of these so-called improvements resulted in a very poor grade of sheets, and were later on abandoned.

The different requirements will now be taken up in order:

1. Sheet mills are strung out in a long line, many mills being driven by one motor or one engine. At each mill the sheet bars are heated in one furnace, are taken across the working floor to the mill and are rolled, first singly, and then in pairs. The furnace in which they are heated is known either as a sheet bar furnace, or more commonly as a pair furnace. When the pairs have been rolled out to a certain length, they are doubled, and reheated in the sheet furnace, which must likewise be located handy to the mill. The customary arrangement of one unit is shown in Fig. 210. The sheets are then rolled to final length. If thin (light) sheets are to be rolled, the pack is again doubled, reheated and then rerolled. After the final rolling, the sheets which have been rolled together, are opened or stripped apart.

From this process it is quite evident that the operating doors of both furnaces must face the working floor side by side, or else be just around the corner.

2. No loose oxide or scale must be formed, because it would spoil both the appearance of the sheets and the surface of the rolls. This requirement means that the furnace atmosphere must be neutral or reducing, no excess of air being permissible in the gases of combustion. Loose scale absorbs and holds products of combustion. This sort of scale breaks in the rolling process, allowing streaks of pure metal to come together and to weld together under the pressure of the rolls. It is thus productive of stickers and wasters.

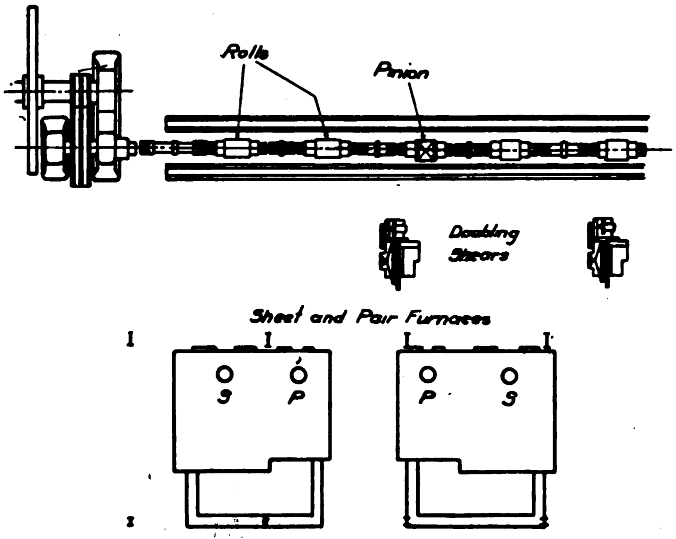

Fig. 210.

3. The requirement of keeping ashes or soot away from the sheets needs no comment, because any foreign material spoils the appearance of the sheets. Ashes injure the rolls also.

4. The requirement that the sheets must have the same temperature at both sides of the pack is easily understood. If one side is colder than the other, the pack will either curl or roll loose, both of which are undesirable. Besides, rolling below the critical temperature causes a cold flow and hardens the material.

5. The requirement of the formation of a very thin layer of magnetic oxide has quite frequently been overlooked, but is nevertheless very essential. The sheets must not have a pure metallic surface, because they will stick together due to the tremendous pressure between the rolls. On the other hand the oxide skin must be so thin and so even that it will stretch

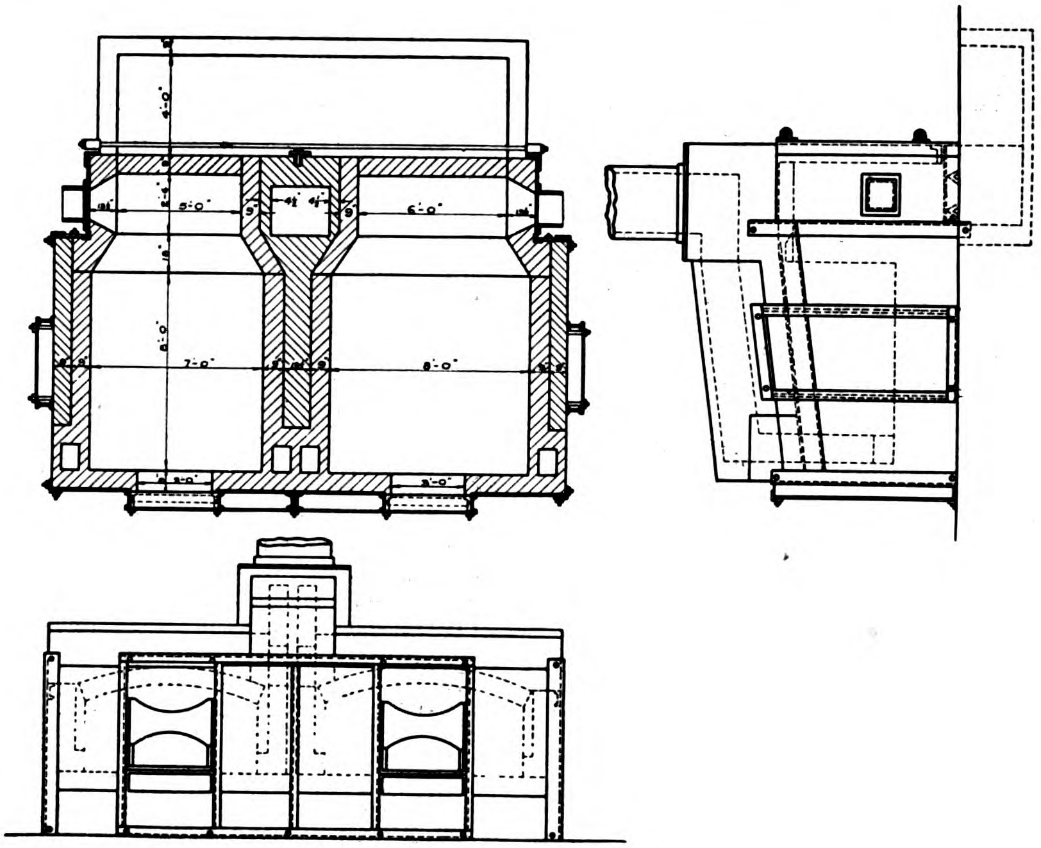

Fig. 212

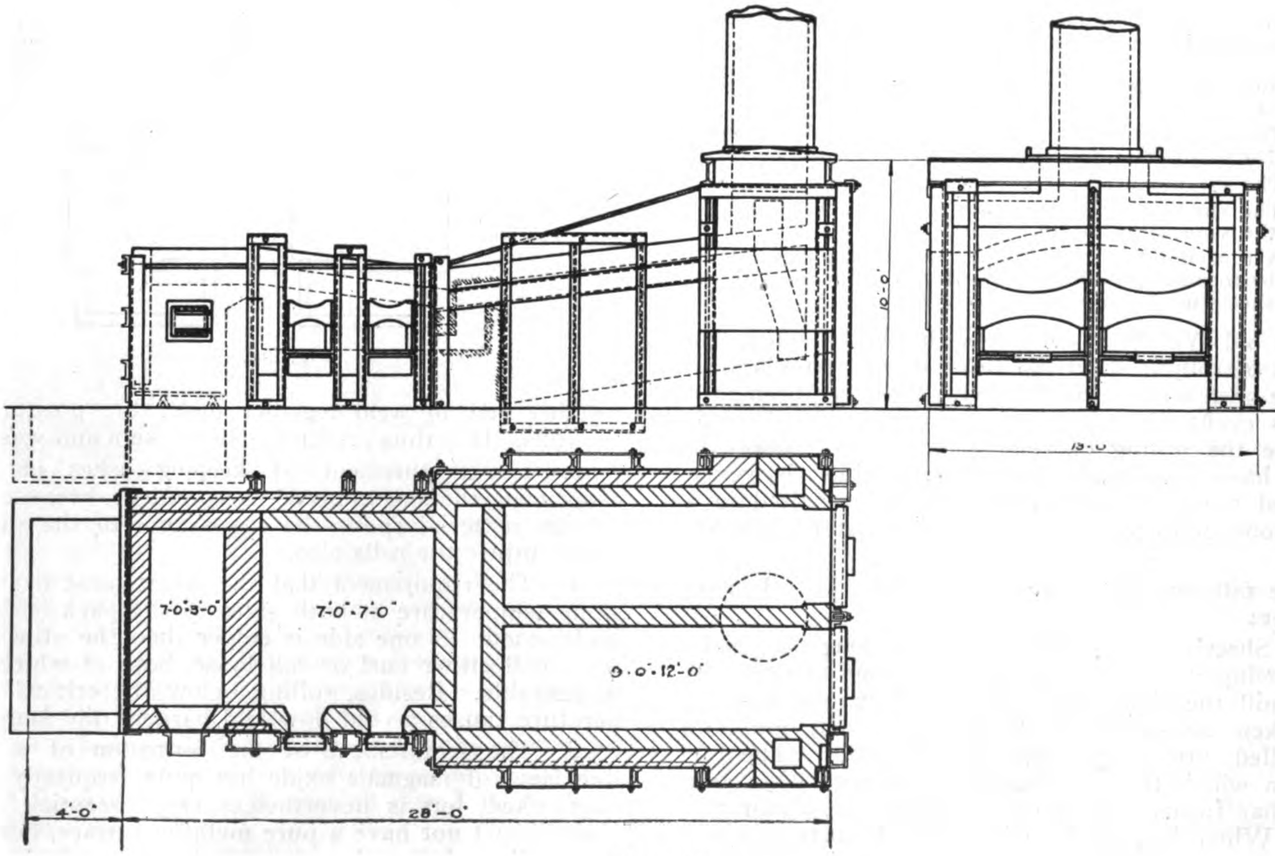

Fig. 211.

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with the sheets without cracking. The oxide coating must stick firmly to the sheets. From all that I have been able to find out, the right kind of oxide skin cannot be formed unless there is water vapor present in the furnace gases.

If that assumption is correct, sheets cannot be heated with a coke fire, unless steam is blown under the fire, or natural gas is burnt with the coke. Whenever bituminous coal is burnt properly, water vapor is present in the flue gases, with little or no free oxygen.

With all of these requirements in mind, the comparison of the different types of furnaces can be made without difficulty.

Fig. 211 shows a combination sheet and pair furnace of a type which was, at one time, widely used, and of which many are still in use. The furnace is hand-fired, the flame spills over a bridge-wall, hugs the roof of the pair furnace on account of its lightness, drops down to opening just above the hearth, rises over a second bridge-wall, hugs the roof of the sheet furnace, and passes out through ports near the doors, at the hearth level. The advantage of this furnace type lies in the utilization of fuel. The pairs (sheet bars) needing a higher temperature than the sheets, are heated by the hottest flame. The disadvantage is, that it is almost impossible to regulate the temperature of the sheets and of the sheet bars independent of each other, and that there exists the danger of air infiltration through the pair furnace, unless pressure is maintained at all times in that furnace.

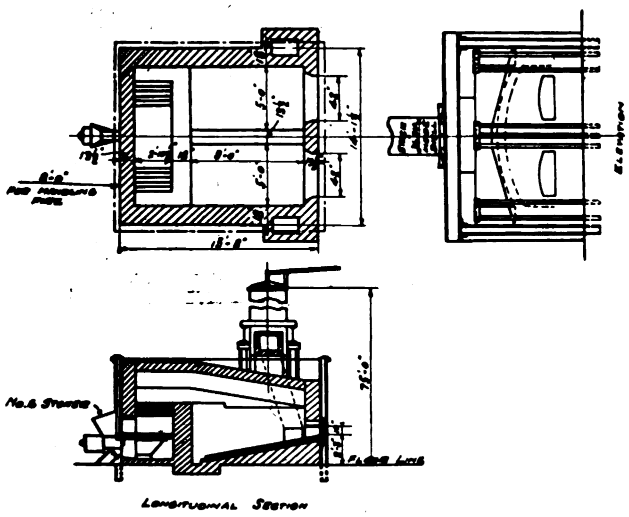

Fig. 213

Many heaters prefer to have the furnaces side by side as shown in Fig. 212. Both furnaces are fired independently, condition of furnace atmosphere can be regulated independently and fires can be cleaned at different times. There is only one stack with one damper for both furnaces, but bricks can be put into the ports of either furnace, and the relative draft conditions can thereby be regulated.

Fig. 126, which was originally published in part XVIII, shows the coal fired end of another side-by-side sheet and pair furnace.

For many years, hand-firing with good lump gas coal was considered to be the only correct method of heat production for sheet furnaces. This method has its advantages and its disadvantages. The flow of air and the rate of combustion can be regulated by the depth of the fuel bed and of the ash bed, in conjunction with adjustment of the stack damper. The heater knows that the fire needs attention every 35 to 45 minutes; there is no chance of the fire changing suddenly in its character. By making the grate surface large, 20 to 25 per cent of the hearth area, the designer can enable the heater to work with a slow fire. In that case the fuel bed acts like a gas producer, and yet uncombined oxygen will pass through the voids, between the lumps of coal. Stratified parallel streams of excess combustible and of unconsumed air, rise from the fire with the low velocity of two feet per second and do not mix to any extent until the flame rolls over the bridge wall.

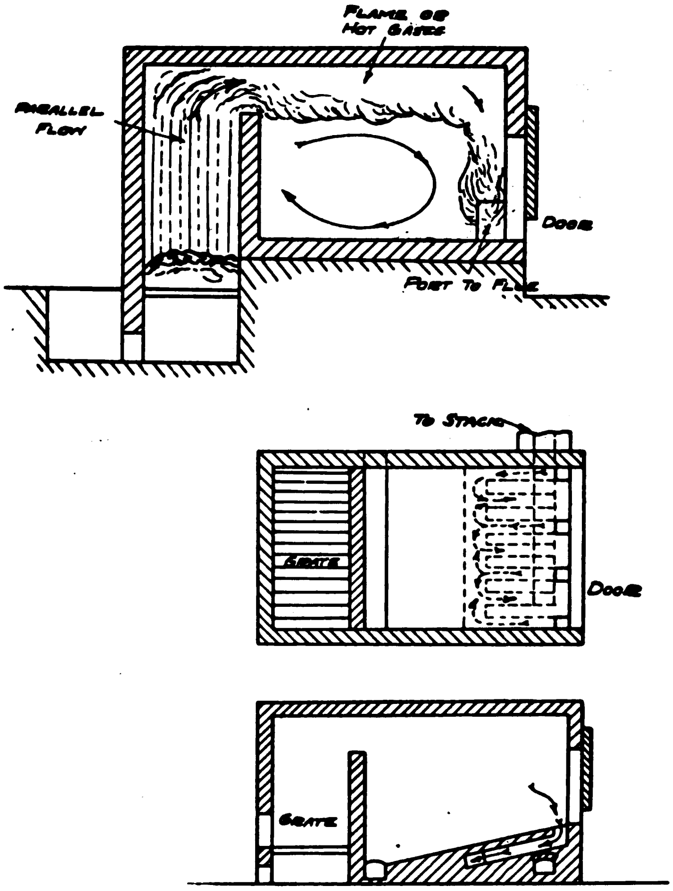

Fig. 215

The flame is always hotter, and in consequence, lighter than the rest of the gases in the heating chamber. If the flame is the least bit smoky, it can be seen rolling along the roof, acting like an inverted river and burning as it rolls along. The temperature of the flame is practically constant so that front and rear of furnace have the same temperature. The flame moves down the front wall, and occasionally licks out through the door which, by necessity, must be open most of the time, at least in the sheet furnace. A hood over the door carries off the little tongues of smoke and flame. There is still a large amount of

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The question of formation of scale has been investigated by Prof. Kowalke of the University of Wisconsin. In a paper before Wisconsin Gas Association, March, 1919, he gives the equation for formation of magnetic oxide by water vapor;

$$3Fe + 4H_2O = Fe_3O_4 + 4H_2.$$

combustible matter in the flue gases when they leave the furnace; flame and black smoke frequently appear at the top of the stack, particularly at a time immediately after firing.

While many mill superintendents still prefer hand-firing, others prefer underfeed stokers, particularly the old "American Underfeed" which is now being built by the Combustion Engineering Corporation, and is being sold by the G. H. Hagan Company of Pittsburgh. Successful hand-firing requires good lump coal; slack will not do, while the underfeed stoker can burn slack quite successfully. Both users and builders of that stoker state that a ton of sheets can be produced with 100 to 150 pounds of coal less than if hand-firing is used. However, the stoker requires just as careful operation as hand-firing does. Some heaters say that it requires even more careful attention than hand-firing does. If it is properly adjusted and if the ash pit doors are kept closed, blast from the tuyeres escapes into the ash pit and crosses the grate bars again further from the center. While the type H Combustion Engineering Corporation stoker is at present the best furnace stoker on the market, it is far from being perfect. It is equipped with hanging clean-out doors which admit excess air, if there is the slightest suction in the combustion space. In some of the plants, the heaters keep these doors mudded up with clay. Furthermore, the stoker is not self-cleaning and requires as much labor as hand-firing does with respect to cleaning. The Jones stoker, which is now being built by the Underfeed Stoker Company of America, has the great disadvantage that there are dead plates at both sides of the tuyere box. Combustion is localized, high temperatures are localized and clinkers are formed. However, I understand that these defects are now being remedied.

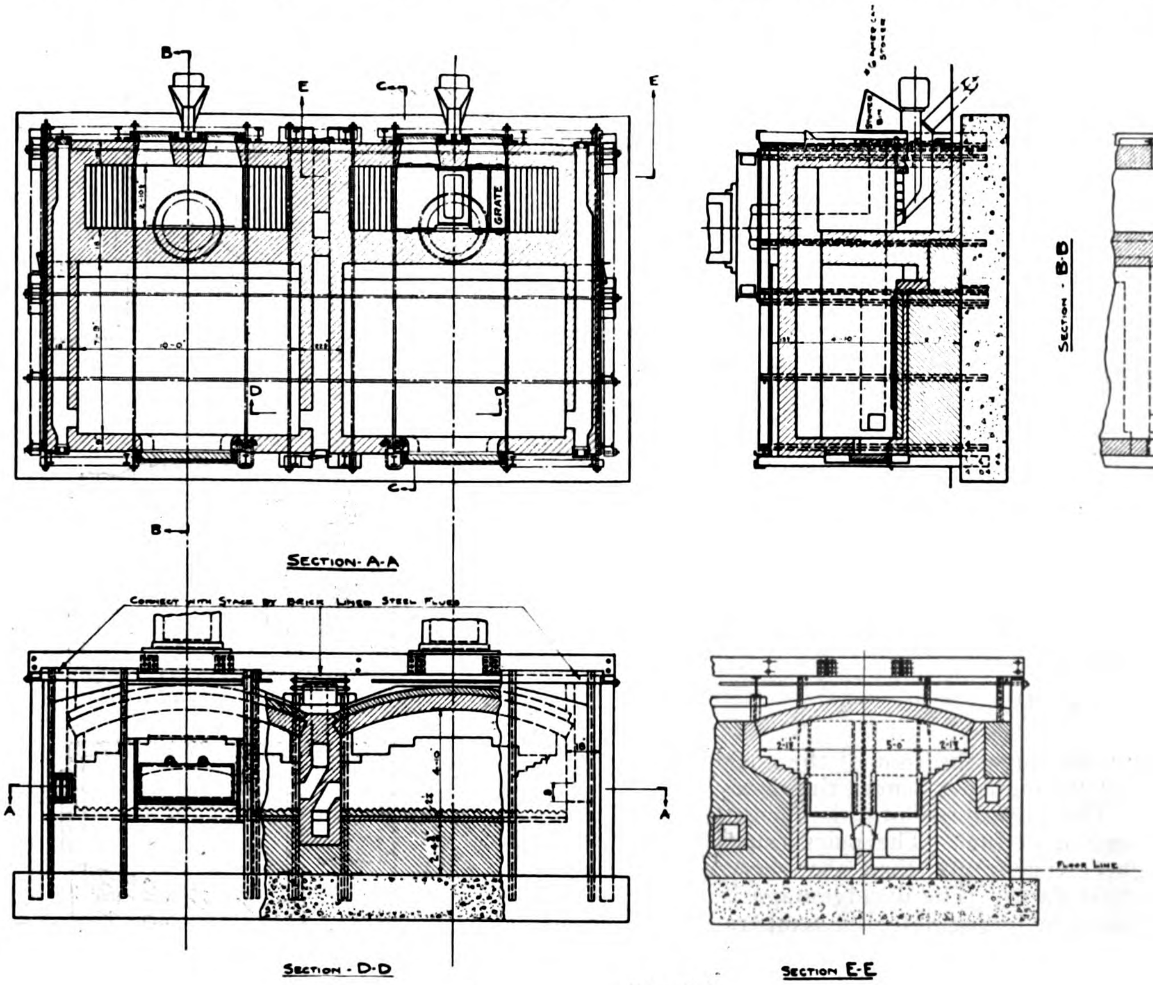

Fig. 214

Two types of furnaces are shown in Figs. 213* and 214. Fig. 213 is a single furnace with a dividing wall, while Fig. 214 shows a double furnace. The divided furnace is liked by many heaters because it furnishes more wall space against which to lean sheets. When sheets are first put back into the furnace they are stood against the wall ("worked against the wall"). This feature, by the way, determines the minimum height of the furnace. Then as the heat progresses the heater flops them down on the hearth, thereby obtaining exposure to the radiant flame on both sides. With heavy packs of sheets, this handling and flopping around of the material is a hard, heavy and hot job, which requires relay teams, each man working only a short time in front of the furnace. The day will come when continuous sheet mills and continuous sheet furnaces will be built, in spite of the tremendous difficulties which must be overcome, and then all of this hard and unpleasant work will be done away with.

The inclined floor in Fig. 213 is found in many other sheet furnaces. It makes possible the use of a lower bridge wall and increases flue gas circulation

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*Furnished by the G. H. Hagan Corporation.

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in the furnace, which fact will be more fully explained below. The inclined hearth is also supposed to afford easier manipulation of the sheets.

Fig. 214 shows several features which are found in good sheet furnaces. It shows the corrugated tile, and clean-out flues. The corrugated tile allows circulation of the hot flue gases under the sheets, see Fig. 215.

Viscous drag and heat of the bridge-wall cause a circulation of the furnace atmosphere as indicated by the arrow. By allowing the gases to circulate through the corrugations of the tiles a semblance of a hot bottom is maintained. The corrugations indeed furnish a substitute for the old Welsh hollow hearth. Many heaters contend today, that a hot bottom is necessary for the successful heating of the sheets, particularly if many small ports are provided near the door as shown in a sketchy manner in Fig. 216.

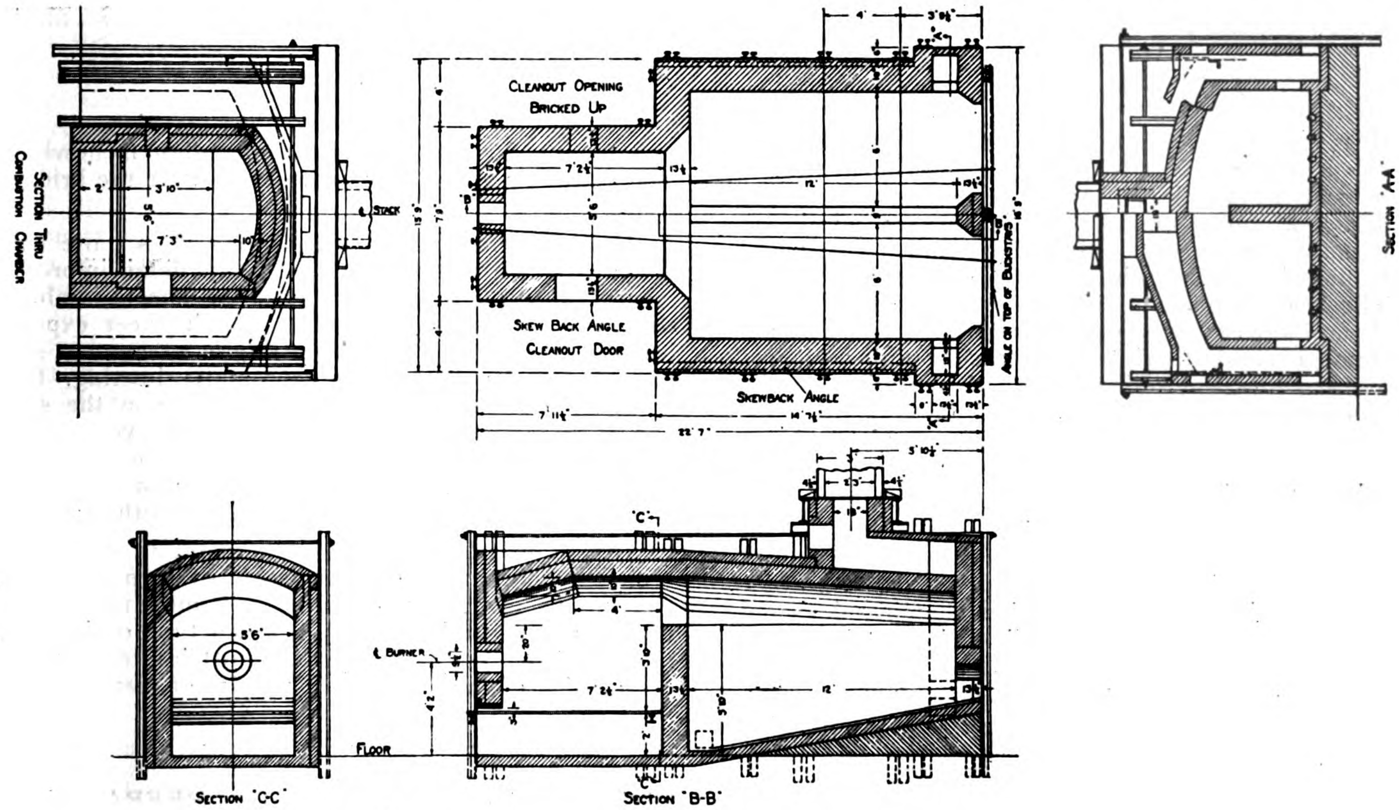

Fig. 217

The underground flues are very desirable if an experienced heater operates the furnace. To make the flue gases heat the hearth from underneath, there must be very little infiltration of cold air around the door. To this end the grate level should be below the door level, and the flue openings must be in the hearth. The stack damper must be so operated that just enough air comes in to allow combustion to reach into the flues under the hearth. This whole adjustment is quite delicate and few heaters can be found to handle such a furnace correctly. If the furnace is improperly handled, the flue gases passing under the hearth actually absorb heat from the hearth and cool it. For that reason the hollow hearth has been given up in most furnaces, in spite of the most excellent service it gives in the hands of skilled operators.

In Fig. 214, there is a groove or pit between the hearth and the bridge-wall. Dirt and scale are blown into it from the hearth by steam or compressed air after every heat, or once a turn. When the pit is filled, it is cleaned out through the cleanout opening provided for that purpose.

Powdered coal has been used for sheet furnaces, but it is not an unmixed blessing. Fig. 217 shows a furnace in which powdered coal is burnt.** The difficulties which had to be overcome in the general use of powdered coal were discussed in part XVII. In the heating of sheets additional difficulties arise. The most important of these is the trouble experienced with the ash. The latter settles on the sheets and is rolled into their surface, spoiling them, and ruining the rolls. In some places the ash is swept off with a common broom immediately after the removal of the sheet from the furnace. That process, however, does not remove ash that settles between the doubled sheets when they stand up against the walls. In some plants, ash sticking to the roof is removed after each heat, to prevent its falling on the sheets and causing uneven heating.

A second trouble arises from non-uniform grinding. Unburnt coarse particles are carried over into the heating chamber and land on the sheets. The remedies are finer grinding and large combustion chambers. Those sheet mills which have had success with powdered coal owe that success partly to large combustion chamber. The combustion chamber of

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Incidentally, Fig. 215 shows that most of the heat is transmitted to the sheets by radiation, and comparatively little by convection, because only a fraction of the products of combustion circles around in the furnace, while a greater part of the gases passes right out to the flue.

**Falcon Steel Company, Niles, Ohio.

Fig. 217 was originally smaller, and was later on increased to its present size.

A third trouble comes from excess air. It will not do to leave the bottom of the combustion chamber open and to let air find its way into the furnace as it pleases. The supply of air must be under control just as much as the supply of coal. The injurious effects of excess air in a furnace heating thin sheets are quite evident. Insufficient mixing of the powdered coal with the air has a similar effect. Powdered coal, as a rule comes in through a single round burner, which is as a matter of fact only a hole or an orifice. It is rather difficult to have a uniform coal-powder and air mixture over the whole furnace width, as that mixture passes over the bridge-wall. This problem, likewise, is brought nearer a solution by a long combustion chamber. Uniform delivery of powdered coal is likewise of greatest importance. In some systems of coal distribution, slugs or gulps of coal arrive at times and seriously disturb the mixture. In one sheet mill using powdered coal and spoiling a lot of sheets, I sifted the coal through standard sieves and found a surprisingly large amount of very coarse and heavy particles in the powder.

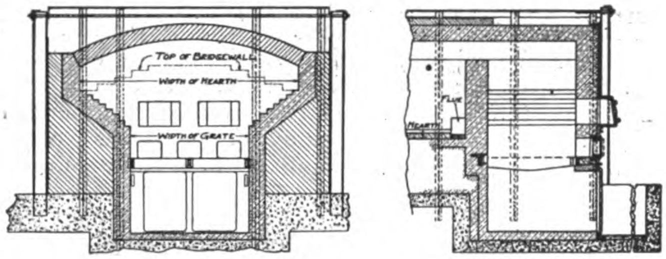

Fig. 216

It can be most emphatically stated that it will never do to use cheap and imperfect grinding equipment and to stick a pipe carrying a coarse powder through the back of a combustion chamber designed for hand-firing. The results will and must be disastrous.

With almost any method of firing, or fuel, it is possible, only too possible, to produce a hot combustion chamber by completing combustion in that chamber. In that case the roof over the combustion chamber is very hot, while the roof nearer to the working door is comparatively cold. Equal and uniform temperature in the heating chamber can, in this case, be procured by carrying a false roof or perforated arch some distance into the heating chamber, see Fig. 218. However, this arrangement is a make-shift and is unnecessary, if a long lazy flame is used. The free end of the perforated arch has a tendency to collapse. With producer gas or with natural gas, the long lazy flame can be obtained by the use of a double bridge-wall through which air is admitted by means of an adjustable door, see Fig. 219. Again, this is an expedient which should not be necessary, because large enough gas ports and air ports can readily be provided in the combustion chamber to produce parallel stream line flow so that the combustion is nowhere near complete when the mixture rolls over the bridge-wall.

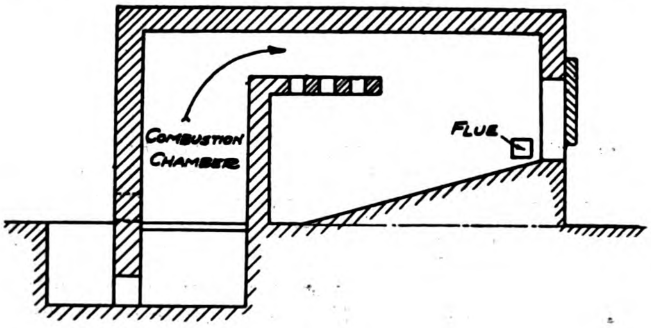

Fig. 218

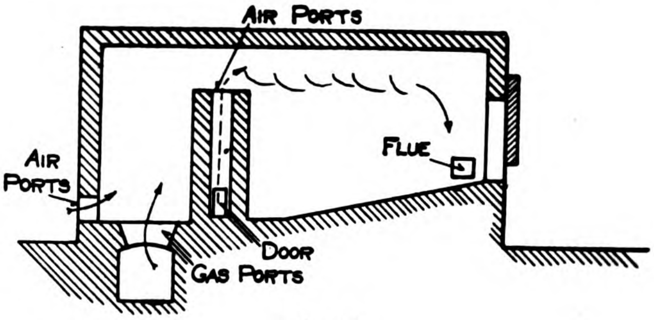

Fig. 219

From the foregoing explanations it is quite evident that, with the exceptions of a few detail improvements, the general method of heating sheets is about the same as it was when the Welsh sheet experts brought the art across the Atlantic. We are still quite far from continuous, automatic heating, free from hard labor and we still depend upon the skill and the eye of the heater as much as ever before. There has been some progress made in the automatic heating of sheet bars. The discussion of the types developed for that work will be left to another article.

In judging the present installment, it should be remembered that it is a discussion of furnace types, and not an investigation of the best methods of producing excellent sheets with a given type of furnace. Such an investigation should be most interesting, but lies outside of the scope of this series of essays.

HIGH HEAT-CONDUCTING REFRACTORY MATERIAL.

A refractory material has been produced at the Perth Amboy, N. J. plant of the Carborundum Company which has a high heat conductivity. It appears that in a sheet metal porcelain enamelling furnace in the plant of the Gribben and Sexton Company, Chicago, it took but six sours to bring the muffle interior up to 1,800 degrees F. A result is that the furnace is now shut down over week-ends because of the relatively small amount of time necessary to bring it up again to temperature. Claims are made of savings in fuel consumption and in increased furnace production, as compared with the fire clay muffle, but exact figures are not available yet. The material has been given the name Carborfax. It is understood the material is also in use for the roof of open hearth furnaces, but here, of course, for its durable refractory property and probably not for heat-conducting capacity.

The Donetzbecken Region of the Bolshevic Government

By DIRECTOR M. ULLRICH.

NOTE—*We are recommending this article to the special attention of our readers. The author was employed in an iron and steel industry of the Donetz region and his work from September, 1918, to October, 1920, with the Soviet government of the Ukraine as assistant to the director consisted in furnishing technical material to the Donetz region. In this capacity he has had wonderful opportunity to become thoroughly acquainted with the conditions described by him.*

SINCE the ending of the Russian revolution and since the beginning of the Bolshevic expansion endeavors the red armies have fought furiously for the possession of the Ukraine and more particularly for its eastern sections which surround the Dontezbecken region. The fury of the struggle is easily explained from the high value of possession of these sections for the Soviet government. Kijew-berditschew between Ukraine and the Black Sea on the south and the line Charkow-Jekterinoslaw-Kriwoi-Rog on the East with its fertile black soil and its very moderate climate is an economically fertile district the production of which is increased by the quick wit of its occupants in Southern Russia. The possession of this economic center, particularly its east is so exceedingly valuable for the Bolshevists because Donetzbecken region is for Soviet-Russia what the Ruhr district is for Germany. It shows in a geological formation particular deposits of bituminous coal and in addition, strata of zinc ore and of veins containing lead, silver and mercury, as well as the valuable deposits of salt. Very favorable for that section is the immediate neighborhood of coal and ore. Industry in this section is quite young but since it started out from the very beginning with modern plants and modern equipment the production figures gained rapidly before the war. In January, 1901, the Dontezbecken region produced 11.3 million tons of coal, in 1915 it furnished the following:

Product	Per Million Tons
Coal and anthracite	28
Steel	2.457
Pig iron	2.72
Semi-finished material	2
Finished material	0.23

The Kriwoi-Rog section produced in the same year 5.36 million tons of ore.

The largest mines are:

Name of Mine	In Million Tons
New Russian Company in Jusowka	1.12
Union Company in Makejewka	1.354
The Russian-Belgium Co. in Jenakijewo.	1.152
Brjansker Company in Jekaterinoslaw	0.992
South Russian Coal Co. in Gorlowka	0.96
Kriwoirog Company in Almasnaja	0.56
Steel Works in Dneprovienne	1.12

The efforts of the Soviet government to get possession of the Donetzbecken region are for this reason quite clear. The Ukraine should furnish coal and ore for the factories in the interior of Russia particularly for the reconstruction of the railroads. Without this supply reconstruction is absolutely impossible because the only other coal district which might be considered fairly is the one near Moscow which furnishes insufficient quantities of a low grade fuel. The final occupation of the Donetzbecken region meant for the Soviet government a success which relieved them of quite a load and brought the prospect of obtaining sufficient production for putting the prostrated north region industry back on its feet. The Soviet government thereby accepted a large and fruitful task of organization, in which however, it fell flat although it pretends in its economical policy to emphasize organizing work on a large scale.

When Denikin in the winter of 1919 was vanquished by the shock of the red army and was compelled to finally give up the Dontez region he blasted not less than 247 bridges in this district. For that reason, it was impossible for the Bolshevists to get into communication with the coal mines from Charkow. It was not until April, 1920, that sufficient communication was obtained so that inspection of the mines by representatives of the government could take place. Their reports showed a very sad picture. The condition of the mines was hopeless. All of the mines were without engineering direction because Denikin has taken along most of the engineers from Ukraine. The first task was then to bring together the required engineering personnel for competent direction of the mines. True to Bolshevic style, all the authorities in the Don region and in the Kaukasus were ordered to determine quickly the number of available engineers and to send all of them without delay to Charkow where the distribution was to be made to the different mines of the Donetz region.

The latter was subdivided from the Green table into 16 sections all of which were to be governed from Charkow. The directors of each section had to be strictly loyal communists. They have to report on their activity to the Soviet government in Charkow but have quite extensive plenipotentiary powers and work responsible without paying much attention to the directions of the central administration. Since there exists no mining engineers, which at the same time are communists, the sections are responsibly directed by miners or by pickmen or laborers which of course must be communists. The assistant to such a director must of course be a mining engineer or an experienced foreman. The direction of the individual mines is taken care of by the commission of three men, the operating director, a workman and a representative of the union. True enough, the Soviet government has come to the conclusion and admitted that these commissions do not satisfy the requirements and that only a strong direction can operate the mines in a responsible and paying manner. Under the present conditions, it is utterly impossible for the director to do any useful work because all local authorities and organizations, no matter if they have official business with the mines or not, consider it their duty to mix in with the internal affairs of the individual works. In this manner the tor-

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From Stahl und Eisen.

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mented director is often busy all day long answering questions and reproaches of bloody laymen and making reports to them concerning his measures. The operating instructions gives him authority to refuse admission to troublesome intruders but this authority is solely a paper authority. Actually he must not dare refuse if he does not want to gain the reputation of being a counter revolutionist and to expose himself and his family to great danger.

This condition of the industry can be summarized as follows:

1. The supply of food for the workmen is very bad, almost impossible.
2. That the supply of machinery for the mines is wholly insufficient.
3. That the organization of the administration of the mines is far from being satisfactory.

When the Bolshevists in the first half of the beginning of the year 1919 for the first time occupied the Donetz region they closed all the large mines but operated only the smaller mines because of past experiences they would appear in position to produce more coal than the large works with their almost wholly destroyed organization. During the spring of 1920 the same method as was first worked out but was again given up in August. From this time on the smaller mines were shut down so as to turn their operating equipment including all boilers, pumps, engines, etc., to the large mines. As might be expected, this measure soon turned out to be a great mistake because the large mines on account of their tremendous requirement, of mechanical equipment could not be made sufficiently operative in spite of the turning over of equipment from the smaller mines; and could scarcely produce their own fuel requirements, whereas the smaller mines, which up to that time, could at least produce some coal were entirely eliminated. The expected increase in coal production, therefore, did not materialize, and yet Soviet-Russia was yelling for more coal. However, for the government the Donetz region is in fact the land of the "black gold" as it is repeatedly called in its popular pamphlets and bulletins and the government knows very well that no matter what happens it must produce the necessary raw material in the Donetz region if the railroads and factories still in operation in Russia are not to be condemned to shut down. But most of the large mines are drowned and under water and there are not large enough pumps to pump them dry. It is true that during the year 1920 four large pumps made in Switzerland had arrived in the region which had been laying in Archangelsk during the war and were distributed to some of the large mines but the installation was utterly fruitless because the necessary motors for driving them are non-existent. There are large quantities of motors around the mines but they all need repair and cannot be operated because the required insulating material and wire are non-existent. The works need gas and water pipe, boiler tubes and copper tubes; electrical equipment is not to be had. Wire cable is lacking. Everything which is necessary to maintain or to start operation is absent. On account of lack of wire cable the mine cages which were formerly operated in four stories only work in one or two stories which of course limits production considerably. Furthermore the mines originally need at least 3000 steam boilers inasmuch as the present boilers are absolutely useless. Never a week passes without a boiler explosion. In order to equip mines, the operation of which the government wishes to maintain, with the necessary boilers, boilers in good condition are taken from other factories and thereby those factories are immediately condemned to shut down. A so-called chock group of about 30 mines has been formed to which all available equipment is given and even that group does not obtain even 10 per cent of its requirements, although continually numerous representatives of the central administration, are hunting around everywhere in the Don region, in the Ukraine at Black Sea ports, to find mechanical equipment and to send more valuable material into the Donetz region. As far as the cost of production of the coal is concerned no correct calculation can be given because the prices of production equipment are simply fixed to suit by the requisitioning authorities. The machinery, of course, is not bought, but requisitioned from offices and factories; just like the boilers it is taken from one factory to be sent to another one the production of which is in most cases very questionable. Although Russia is so rich in large forets, the Donetz region is lacking the necessary lumber as well as mine timber. It is true that whole train loads of mine timber are sent from the region of Minsk and Pinsk but very few cars of these trains reach the Donetz region in filled condition, because most of it is stolen on the road. Of course, the quantity of produced coal is very insufficient in the event of this condition as the following table shows:

Produced Coal in Thousands of Pud of 35-Pounds Each.

Year 1920	Coal	Anthracite	Total
April	10,797	2973	13,770
May	13,857	4714	18,571
June	18,371	2184	25,555
August	15,522	7171	22,693

At the Same Time the Number of Men Employed Was in 1920

1920	Miners	Workmen below ground	Workmen above ground	
April	16.164	31,697	57,489	105,530
May	15,149	32,054	67,345	108,231
June	16,266	33,627	67,345	117,838
August	16,202	36,015	72,456	124,673

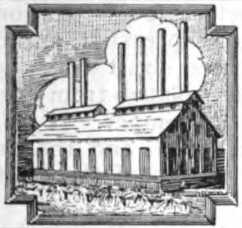
The government is conscious of the fact that the supply of foodstuffs for the rest of Russia depends upon coal production and that lack of coal will not permit them to export the grain from those parts of Russia where it is still plentiful. The government also endeavors to bring up the monthly coal production to 40,000,000 puds but this endeavor seems to be utterly hopeless with the present condition of organization and administration. The government will not have to make tremendous efforts to maintain the present rate of coal production. Since 1916 coal production has changed as follows:

Reduction in Tons.

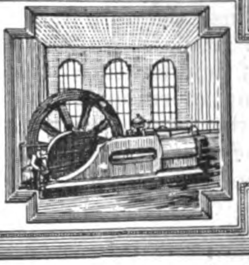
1916	1917	1918	1919	1920
28,016	24,000	4,544	2,192	2,400
Average Monthly Production of Each Miner in Tons.				
10,232	8,960	4,832	3,840	2,816
Number of Workmen.				
126,000	114.000	94,000	57,000	110,000

The condition of the steel industry is still more hopeless than that of the mining industry. Almost all steel works are shutdown. The government cannot operate them on account of lack of fuel. The production of coal is too small to make any coke, and ore cannot be brought to the works on account of the sad conditions of transportation. Further there is lack of the necessary skilled workers and laborers. The skilled workers prefer to let the laborers do the work for them and lead an easy life as members of steel works committees and as incubants of responsible jobs without doing anything useful. But the laborers shirk hard work which does not even pay them enough to live and occupy themselves principally with profitable secret sales.

(Continued in May issue)



STEAM POWER DEPARTMENT



Development of Mechanical Soot Blowers

Recording Some Most Recent Tests of Mechanical Soot Blowers With Coal, Pulverized Fuel and Oil—Marked Increases in Boiler Efficiency Are Shown by Use of Mechanical Soot Blowers.

By **ROBERT JUNE,**
Mechanical Engineer.

THIS article records some of the most recent tests of mechanical soot blowers with coal, pulverized fuel and oil—marked increases in boiler efficiency are shown by the use of mechanical soot blowers with each of these fuels.

Soot, it has been stated, is the best heat insulator known, being more than five times as effective as asbestos in preventing heat transference. Those of us who have to deal with the soot problem continuously, know that this statement is literally true. You can no more expect efficiency out of a boiler, the fire surfaces of which are coated with soot, than you can expect efficiency from a man with a bad cold. There is congestion and bad circulation in both cases.

If you want to keep up steam when the soot piles up you will have to pile in more fuel. This fact has been strikingly illustrated in some recent tests. Mechanical soot blowers were installed on boilers fired with coal, pulverized fuel and fuel oil. These tests show clearly that clean tubes—clean as only mechanical soot blowers can make them—are absolutely essential to the maintenance of high boiler efficiency.

In this article then, instead of discussing advantages and disadvantages of mechanical soot blowers, questions which center in the design and construction of the equipment we will deal with some actual results secured in typical power plants, and will reserve our consideration of mechanical features and the types of equipment for different boilers until next month.

Test at Large Railroad Shop Boiler Plant — Soot Blowers Save $14,063.05 a Year.

During the winter of 1918-19 one of the big American railways decided that the cost of producing power at one of its large shops was excessive, and that the possibility of effecting a reduction through the medium of mechanical soot blowers should be thoroughly investigated.

Bigelow-Hornsby boiler No. 544, in the west boiler room which was selected for test, is rated at 625 hp. The stoker under the boiler is a Taylor 7-retort underfeed type, having a grate area of 105 square feet, with inclined grate. Forced draft was supplied to this stoker by 1 by 3-inch Sturtevant turbine-driven, multivane, double-inlet fans. In this test the forced draft and the stoker drive were separated and the stoker was driven by one of the Westinghouse engines recently installed on the boiler room floor for the driving of stokers. Induced draft was obtained by means of fans located at the uptake to the stack.

On boiler No. 544, steam flow was obtained by means of two meters, one an integrating-recording-indicating General Electric meter already installed and used in tests, and the other a newly-installed Bailey boiler meter. Weight of coal was obtained from the traveling weight hoppers and lorry tickets. A revolution counter was placed on the Taylor stoker to count the revolutions of the main power shaft. The thermometers for obtaining superheated steam temperature and that for obtaining feed water temperature, were placed in thermometer wells in their respective pipes at the top of the boiler as in previous tests.

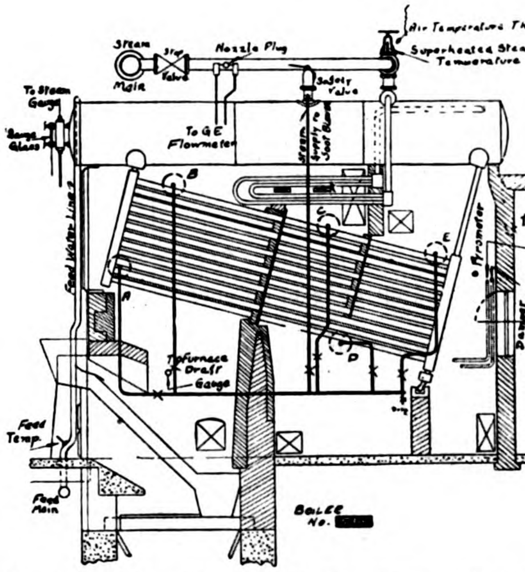


Fig. 1—Bigelow-Hornsby Boiler showing location of recording devices.

Uptake temperature was obtained from three pyrometers inserted into the flue above the damper, and inserted at 4, 5, and 6 feet respectively. The cold junction temperature was obtained by means of an indicating thermometer suspended over the cold junction of the pyrometers. Steam pressure was obtained from the steam gage in regular service in the drum. A steam correcting thermometer for obtaining the superheated steam temperature corrected was used. The carbon dioxide of flue gas was obtained by means of a sampling tube already installed and used in previous tests in conjunction with a standard Orsat gas analyzer. Draft over the furnace and at the damper was obtained on the indicated gage. Pressure in the wind box was indicated on the lower gage and on the recording pressure gage. In addition to the above, the Bailey meter indicated the draft over the furnace and the air flow through the boiler, the latter being obtained by means of two 1½-inch pipe connections, one to the combustion chamber over the furnace, and the other in front of the damper at the same height as the first. The various items indicated above, and constituting the testing apparatus of this boiler, are shown in the accompanying sketch.

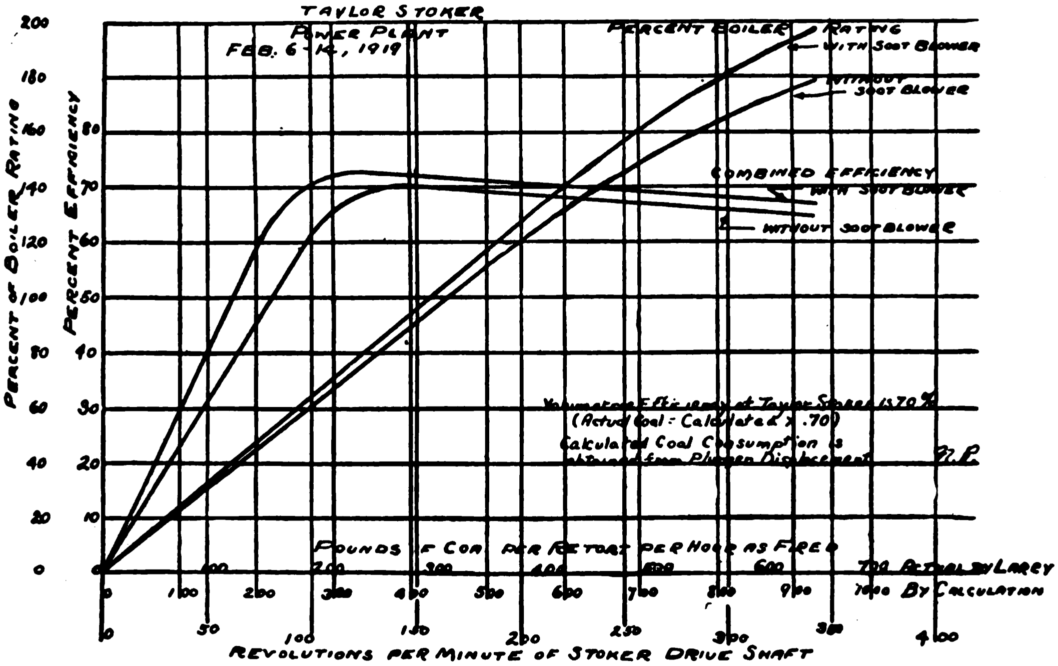


Fig. 2—Result of tests on soot blowers on Bigelow-Hornsby Boiler equipped with 7-Retort Taylor Stoker.

Boiler No. 544 was cut in on the line at 5 A. M., February 3, 1919. The duration of each run was 24 hours. At the beginning of each run the fire was cleaned whenever found necessary by observation of the fire. This varied from about 2 to 4 hours, depending on the load. On this boiler 8 tests in all were made, the first 4 being with soot blowers, and the second 4 being without soot blowers, attempting to reproduce the conditions of the first 4 as nearly as possible.

In doing this the fire-room crew and the tester were guided by the average conditions attained in the first 4 runs. Readings were taken every 20 minutes. The steam utilized by the soot blowers was not registered by the steam flow meters. Readings were taken as follows: steam flow; air flow; furnace draft gage; window-box pressure; the speed of the stoker line shaft; the number of revolutions of the stoker power shaft; steam on three pyrometers; cold junction temperature; air temperature; steam pressure, and carbon dioxide in the flue gas. Forced draft was obtained from No. 3 blower which was isolated from the other blowers by closing the division damper. It was kept running throughout the entire test, and the draft to the boiler was regulated by means of the control at the boiler.

A summary of the principal data and the results of the test on boiler No. 530 is given herewith as Table I. The same material has been tabulated for boiler No. 544, but as it does not differ materially, it is not here included.

Average value of the flue gas temperature for the series with soot blowers is 481.0 degrees F., against 569.0 degrees F. without soot blowers. This represents a decrease of 88 degrees using soot blowers and means that with the soot blowers in operation, the boiler has absorbed more heat from the gases, due to cleaner heating surfaces than without soot blowers.

It has been stated previously that with the present practice of cleaning the boilers with the hand lance, each boiler is cleaned every 4 or 5 days. In the tests on boilers No. 530 and No. 544 without soot blowers, in order to reduce this condition, the series was started with the boiler heating surface clean and then left without any cleaning during the series.

If the series had been extended for, say, an equal period or longer, and if during that period the regular hand method had been used to clean the boilers on the regular schedule, it is very probable that a still greater rise in flue gas temperature and still greater decrease in combined efficiency would have resulted. It is safe to say that a more exact test along the line indicated would show better results.

In addition to the above may be mentioned the fact that operation of soot blowers does not require the banking or shutting down of the boiler, while in

TABLE I.

Principal Data and Results of Tests on Babcock & Wilcox Boiler No. 530 With and Without the Soot Blower furnished by the Diamond Power Specialty Company.

Grate Surface of Roney Stoker (width 12 ft. 6 in., length 7 ft. 6 in.) Equals 94.5 sq. ft. Total Heating Surface (excluding Superheater) equals 5200 sq. ft.

	With Soot Blowers				Without Soot Blowers			
	Test No. 1	Test No. 2	Test No. 3	Composite No. 1 to 3 of Tests	No. 4 Test	No. 5 Test	No. 6 Test	No. 4 to 6 of Tests
1—Date started*	2-6-19	2-7-19	2-8-19	Feb 6 to 8	2-9-19	2-10-19	2-11-19	Feb 9 to 11
2—Duration, hours	24	24	24	72	24	24	24	72
3—Average steam pressure, lbs. per sq. inch gauge	187	187	186.5	......	187	187	189.0	......
4—Temperature of feed water, F. degrees	228	217	223	......	235	194.5	196	......
5—Average steam temperature, F. deg. corrected	425.3	419.3	421.0	......	427.3	436.7	445.5	......
6—Average superheat F. degrees	43.3	36.8	38.6	......	45.3	54.2	62.1	......
7—Average uptake temperature, F. deg. corrected	481	479	484	481.0	502.0	583.0	621.5	569.0
8—Average CO_2 per cent	10.9	11.8	12.8	......	10.4	11.5	12.0	......
9—Moisture in coal per cent	0.85	0.95	0.50	......	......	......	......	......
10—Total coal fired, pounds	43430	48070	58500	......	45105	55350	57540	......
11—Total coal dry, pound	43060	47613	58257	148880	44879.5	54918	56948	156746
12—Dry coal per hour pounds	1794.2	1984	2425	......	1870.0	2288.0	2373.0	......
13—Dry coal per sq. ft. of grate per hr. lbs.	19.08	21.1	25.8	......	19.89	24.35	25.25	......
14—Total actual evaporation lbs.	349080	412632	472968	......	381348	441504	427488	......
15—Factor of evaporation	1.061	1.069	1.064	......	1.055	1.102	1.107	......
16—Total equivalent evaporation from and at 212 deg., F. lbs.	370024	441102	503238	1314354	402322	486537	473229	1362088
17—Equivalent evaporation per hour from and at 212 deg. F. lbs.	15417.8	18379	20968	......	16763.4	20272	19718	......
18—Equivalent evaporation per hour from and at 212 deg. F. per sq. ft. heating surface, lbs.	2.96	3.53	4.03	......	3.22	3.89	3.80	......
19—Rated capacity per hour from and at 212 deg. F. lbs.	17940	17940	17940	(72 hrs.) 1291680	17940	17940	17940	(72 hrs.) 1291680
20—per cent of rated capacity developed per cent.	80.0	102.4	116.9	101.7	93.4	113.1	110.0	105.4
21—Equivalent evaporation from and at 212 deg. F. per lb. of dry coal lbs.	8.59	9.25	8.64	8.83	8.96	8.86	8.32	8.70
22—Heating value dry coal Btu per lb.	13572	14123	13840	13865	13731	14073	13996	13940

*Test No. 1 started February 6 at 9:30 A. M. Each succeeding test started one hour later in the day than the preceding one.

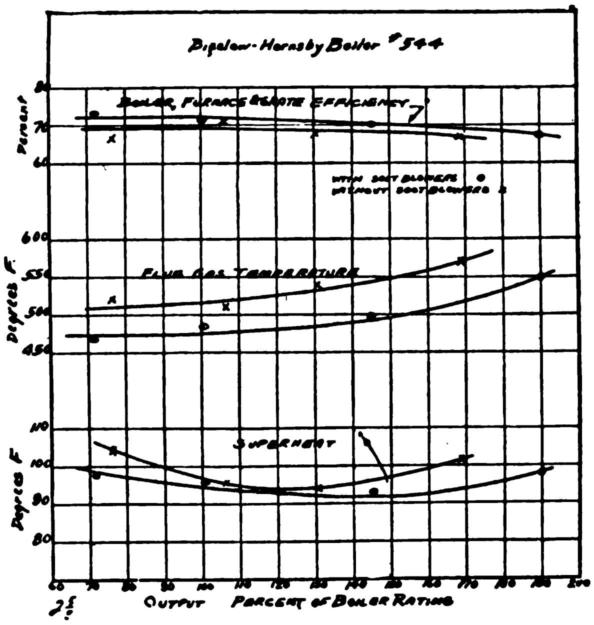


Fig. 3—Graphic summary of results attained by use of soot blowers on Bigelow-Hornsby Boiler.

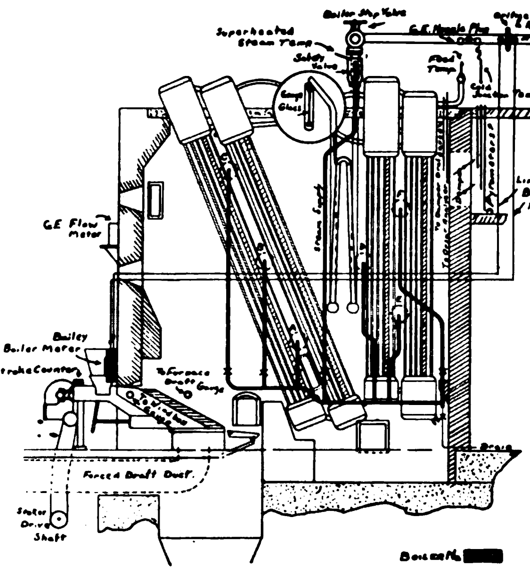


Fig. 4—Arrangement of soot blower units and recording apparatus on Babcock & Wilson Boiler.

order to remove the soot by the hand method it is necessary to shut down the boiler for two or three hours, during which time the boiler setting cools and must be warmed up again. Here is a loss which is eliminated by the use of soot blowers.

In conclusion it should be noted that these tests were conducted in a manner calculated to indicate a minimum rather than a maximum improvement by the use of soot blowers. The tests would undoubtedly have been fairer if the use of soot blowers before making the tests had been refrained from, employing the hand lance only to clean the boilers at the regular periods of cleaning. Had this been done, the boilers would not have had the advantage of being cleaned thoroughly by mechanical soot blowers when they entered the hand-hose test.

Mechanical soot blowers are just as important, just as necessary, with pulverized fuel as with other types. As a matter of fact, in practically all successful installations where pulverized fuel is used, the boilers are equipped with mechanical soot blowers. The tubes should be cleaned by the blowers every 6 hours or oftener. As the temperatures are high, the blowers should be constructed of some such material as calorized metal in order to withstand the hard service conditions. The regular use of mechanical soot blowers will save 4 to 8 per cent of fuel, as well as a large amount of the labor required for cleaning.

Soot Deposits In Oil Fired Boilers.

The soot deposit resulting from the combustion of oil is in the nature of a pure carbon mixed with a slight amount of oil. It is somewhat fluffy in appearance and adheres readily to the tubes, but is easily cleaned and removed from the boiler under the operation of a steam jet. It is entirely different in character from the soot resulting from combustion of coal on account of the absence of ash, etc., and the presence of greater or less quantities of unburned oil, which going through the boiler tend to deposit on the tubes in combination with the soot. If this formation is not removed at regular frequent intervals it soon crystallizes or carbonizes on the tube and must then be scraped off with rods or bars.

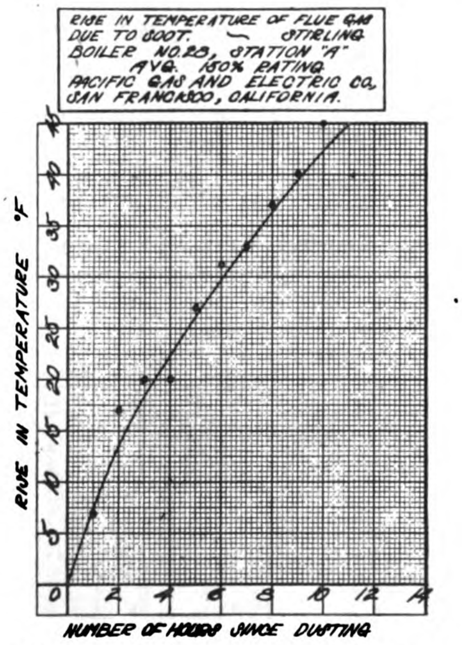


Fig. 5—Rise in temperature of flue gas due to soot.

Soot deposits from oil-fired furnaces have much greater insulating effect than those occurring with coal fired furnaces. There are two reasons for this: First of all, the deposit is in the nature of a pure carbon which has greater insulating properties than various ash constituents found in soot from coal; second, the deposit being of a somewhat fluffy adhesive nature, is usually found to envelope the entire tube as compared to coal deposit which usually consists of soot, dust and ashes building on top of the tube and leaving the underside more or less clean.

For some time after oil came into use for boiler furnaces, the impression prevailed that oil fired boilers did not require as frequent or as thorough cleaning as coal fired. The efficiencies of oil fired boilers were generally higher than those obtained where coal was used for fuel, due to more perfect combustion with a smaller quantity of excess air, and this improvement was for some time accepted on its face value as the best obtainable. With the increasing use of oil as fuel in the past few years, it was inevitable that detailed tests should be inaugurated of the performance of oil-fired boilers with and without mechanical soot blowers.

These tests developed the fact that mechanical soot blowers are absolutely essential to the development of the highest efficiencies on oil-fired boilers. As an example, attention is called to the results of the following test by the Pacific Gas & Electric Co.:

Test Data Before Using Soot Blower.

Time A. M.	Stack	Temperature Sup. Steam	Load Meter
10:15	550	500	4.2
10:30	550	502	4.0
10:45	555	498	4.0
11:00	557	498	4.1

Test Data After Using Soot Blower.

Time P. M.	Stack	Temperature Sup. Steam	Load Meter
2:30	485	495	4.2
2:45	485	506	4.0
3:00	482	504	4.3
3:15	483	505	4.2

Test Results	**Before**	**After**
Before	4.075	4.175
Per cent rating	101.85 percent	105.38 percent
Steam pressure gauge	199.5 lb.	200.75 lb.
Superheater steam temperature	499.5 deg.	502.5 deg.
Stack temperature	553 deg.	483.75 deg.

These results show that the soot blowing caused the temperature of the stack gases to fall from 553 degrees to 483.75 degrees, making a difference of 69.25 degrees or 13.05 per cent.

Also the temperature of the superheated steam was raised from 499.5 degrees to 502.5 degrees a rise of 3 degrees or 0.6 per cent.

The direct effect of the use of soot blowers is a saving of 3.9 per cent.

The Texas Company, Port Arthur, Texas, found a saving of 5.5 per cent fuel by the use of mechanical soot blowers and as a result ordered an equipment for 30 oil-fired boilers. As this company is in the oil producing business its action is particularly illuminating.

These tests were followed by others at some of the large western central stations. On one of these, the boiler, a large Stirling, was taken off the line, and the tubes, superheater, etc., washed clean. The boiler was then fired and an evaporation rate of 37,000 pounds of water an hour, and 14 per cent CO_2 was maintained. At the end of the 24-hours the soot blowers were operated, and were used for 24-hour periods for the remainder of the test with the equipment. During these tests, readings were taken at 15-minute intervals of the water-rate, CO_2, draft, oil and superheat. When using the blowers the flue temperature dropped to 525 degrees and rose to 540 degrees in about 15 minutes. It ranged around 540 degrees for about 16 hours, and then crept gradually up to 590 degrees at the blowing period, when it again dropped to 525 degrees. This was the regular daily performance throughout the test while using the blowers.

At the end of a 7-day period the boiler was given a final blowing and thereafter operated under the usual plant conditions; that is, without any cleaning at all. At the end of the first 24-hours' run, the temperature had risen to 590 degrees; at the end of the week it had risen to 680 degrees, and at the end of 10 days had risen to 720 degrees, at which point it seemed to hold. But they were not able to maintain the evaporation rate which dropped to 34,000 pounds an hour. The saving effected by soot blowers amounted to 6 per cent.

Despite the war emergency, with its constant urge to speed rather than to thoroughness, the Emergency Fleet Corporation made some detailed tests of Diamand Soot Blowers before adopting them. These tests were conducted at Burlington, Iowa, under the direction of the Bureau of Mines.

The boiler selected was the Foster Marine Water Tube, and was one of a large number then being built by the Murray Iron Works of Burlington, Iowa, for the Power Specialty Company of New York, for delivery to the corporation. The tests extended over a period of a number of weeks, and covered a wide variety of operating conditions, with boilers forced to high rating at times, with different conditions and drafts.

In addition to proving the necessity of soot blowers to economical operation, the tests threw some important light on soot blower construction. For instance, in boilers burning fuel oil, draft conditions are very low, running from .02 inches in the furnace up to .08 inches in the uptake. If soot blowers were designed so that all nozzles emitted steam at the same time, a curtain or blanket of steam would be ejected into the boiler at high velocity, with the result that it would either put out the fire or materially interfere with the draft. The bad effects of interfering with the draft can hardly be overstated. As a result of such conditions all of the factors in the operation of the boiler become unbalanced. This applies to the feed of oil to the furnace, the maintenance of even steam pressure, and the injection of the feed water. In place of a normal even operation, a condition of ebb and flow takes place which may last for an hour or more before conditions again become normal. Necessarily, this entails work on the part of the fireman who finds the whole routine and operation of the boiler room upset.

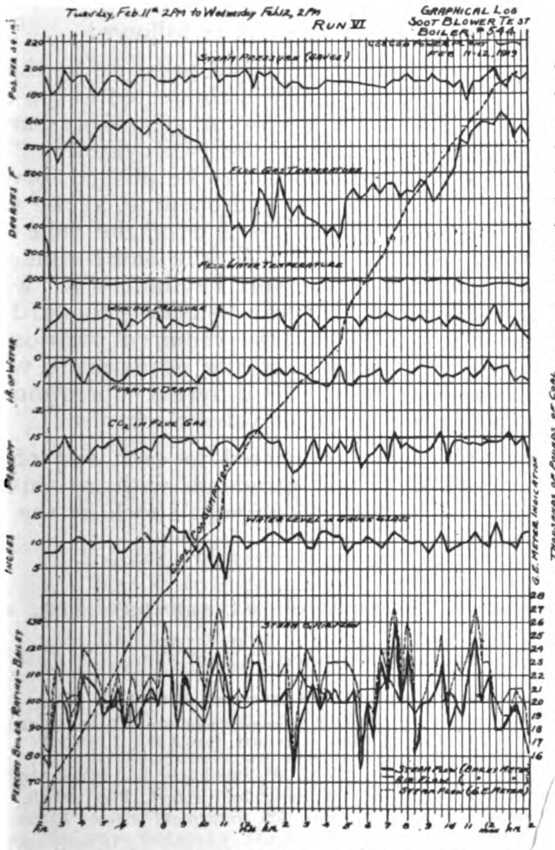


Fig. 6—Typical graph showing conditions test of soot blower.

In order to take account of this condition the soot blower for hollow-staybolt boilers is made up in vertical sections, each under the control of its individual valve. This arrangement permits of blowing three or four vertical rows of tubes at one time, thus avoiding all interference with the draft.

On stationary boilers of the horizontal water-tube type, vertically baffled, and on vertical boilers, where revolving soot blower units of the Diamond Model G type are commonly used, the use of fuel oil calls for little change in construction. Care is taken in locating the units to be sure that they blow with the draft. In addition, it is sometimes found advisable to stagger or offset the blower nozzles so that they do not all blow in the same direction at the same time.

As a result of the Burlington test, hundreds of oil burning vessels built by the Emergency Fleet Corporation were equipped with mechanical soot blowers. In conclusion, the mechanical soot blower for oil-fired boilers is here to stay, and the use of blowers on such boilers is fast becoming as common as the use of blowers on coal-fired boilers.

Table II.

Comparison of Composite Results With and Without Diamond Soot Blowers.

Decrease in average uptake temperature with soot blowers....	88 deg. F.	36.1 deg. F.
Percentage gain in efficiency of boiler furnace and grate with soot blowers	2.15%	2.05%
Value of savings of coal per year based on 1918 consumption and prices:		
In West Boiler Room..................		$ 8,559.86
In East Boiler Room..................		5,503.19
Total saving........................		$14,063.05

The exact effect of moisture in connection with spontaneous combustion is not known and the evidence of laboratory experiments is contradictory. The repeated wetting and drying of coal seems to increase the tendency to spontaneous combustion. This may be due to the breaking up of the coal which such alternate wetting and drying occasions, even if there is no chemical reaction between the water and the coal. It is not wise to put coal into a pile, or to store coal on a damp base if it can be avoided. After a rain or snowstorm a coal pile should be carefully inspected and watched.

EDITOR'S NOTE—Due to an error in the composing room in making up the last issue of THE BLAST FURNACE AND STEEL PLANT, the photographs used in connection with the George T. Ladd's article on "Installation of World's Largest Boilers," were not placed in the article in the position corresponding to their mention in the text.

NEW CONTROLLING VALVE FOR OPEN HEARTHS.

(Continued from page 253)

do nothing to assist the proper mixing of the air and the gas.

The usual practice is to deliver the air and gas to one end of the furnace by separate flues, the air flue being directly over the gas flue. This arrangement is adopted with the idea that the difference in specific gravity will cause the mixing of the two. This result might be achieved were it not for the counteracting influences produced by the manner in which the air and the gas are brought to this point.

The gas is delivered from the producers at a pressure of approximately 1-inch W. G. The delivery of the air is solely dependent upon the amount of the stack draft, which must be maintained sufficiently high to draw the air through the valves checker chambers and flues. This draft pressure continues to exert its influence on both gas and air after the entrance to the furnace is reached, tending to draw them along in a straight line at a high velocity, thus preventing proper mixing. In order to overcome this counteracting influence, it is necessary to deliver the incoming air and gas to the furnace entrance at approximately the same pressure. The draft pressure could then be reduced until there is only sufficient to carry away the waste gases and attain a desirable flame-speed through the furnace. By this arrangement of forcing the air through the checker chambers better regenerating efficiency could be obtained and the present limitations in the design of regenerative chambers removed.

The difficulty of achieving this condition has been overcome by an ingenious arrangement in the form of a reversing valve combined with air-pressure and volume-controlling mechanism, for which applications for patent have recently been filled by W. H. Wharton, Consulting Engineer on steel plant equipment for Canadian Allis-Chalmers, Limited, Toronto.

A description of this valve, the method of operating together with illustration are given below:

Figure 1 is a plan of the complete valve and mechanism, one-half of the plan being shown in horizontal section, the whole plan being symmetrical about the centre line.

The valve chamber "A" consists of an arrangement of cast plates or other suitable construction, the same being brick-lined as to walls and roofing; the whole for the purpose of covering and separating the three different flues "B", "C" and "D", two of which, i. e. "B" and "C" lead in opposite directions to the two regenerative chambers situated one at either end of the furnace, the third flue "D" being connected to the chimney stack. These flues are separated by the partitions "E", "F" and "G", the partition "E" being made of a combination of brickwork and steel. The partitions "F" and "G" are hollow cast-sections filled with water. Each of these partitions "F" and "G" are constructed in such manner as to provide a seat for the valve when closed and to provide an opening for the easy passage of hot gases to the stack when the valve is open. Across this opening, pass four bent, hollow, tubes "H" all meeting in the centre of the opening, forming a hollow boss "J" which supports and connects the hollow shaft "K" to the four connecting tubes or arms "H". This hollow shaft "K" forms the valve stem upon which is supported part of the weight of the valve "N" and upon which the valve moves to and fro as operated. Another function of the hollow shaft "K" is to provide a means of conveying cooling water to the respective partitions "F" and "G" from which the water passes out by means of pipe "M", provided in a suitable location for that purpose.

The valve body "N" is made of cast iron, steel or other suitable material, suitably designed in order to impede the velocity of the air as little as possible, at the same time to offer the maximum surface possible to the cooling influence of the passing air. From the valve body "N" there is an extension tube "O" for the purpose of conveying and conducting the passage of the air chamber "P" through the valve into the respective flues "B" and "C". The tube "O" is connected by a hollow piston rod "Q" to the piston "R" which is operated back and forth in cylinder "W" by air or steam pressure.

The air-regulating device consists of two circular cones or valves "S" and "T" suitably connected and operated by the small piston "U" and connected thereto by the piston rod "V". On this piston rod "V" is fixed an adjusting wheel "Y" for the purpose of adjusting the length of travel of the air-regulating cones "S" and "T".

The operation of the valve is as follows:

Air is supplied at the required pressure to the air chambers "P". Water supply is connected to the ends of the hollow shafts "K". Air or steam pressure is admitted to opposite ends of the two cylinders "W", causing one of the valve bodies to be pushed forward into its respective valve seat and opening, at the same time admitting the air to the end of the tube "O" from the air chamber "P". At the same time, the pressure is admitted to the small cylinder "X" which operates small piston "U", thus pushing forward the two cones "S" and "T" to the required position, as determined by the setting of the adjustment wheel "Y". The reverse of these different operations is meanwhile placed on the other valve mechanism.

The exhaust pipes connected to each end of the two cylinders "W" are provided with a suitable cushioning arrangement to prevent shock at the end of each stroke.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

[Required by the Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly at Pittsburgh, Pa. [Report for April 1, 1921.]

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Editor—Donald N. Watkins, 108 Smithfield street, Pittsburgh, Pa.

Managing Editor—F. C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

(Names and addresses of stockholders holding 1 per cent or more of total amount of stock.

Estate of H. A. Andresen, Care Colonial Trust Co., Pittsburgh, Pa.

Fred C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

L. L. Carson, 108 Smithfield street, Pittsburgh, Pa.

R. H. Thiess, 108 Smithfield street, Pittsburgh, Pa.

M. M. Zeder, 108 Smithfield street, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

FRED C. ANDRESEN, Business Manager.

Sworn to and subscribed before me this 21st day of March, 1921.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1923)

FOREIGN RELATIONS

THE IRON ORE MARKET OF BILBAO IN 1920.

A recent article in Informacion, the official organ of the chamber of commerce of Bilbao, states that the ore market at that place during the year 1920 was very satisfactory and brought significant profits to the mine operators in spite of high prices of coal and labor difficulties which prevailed throughout the greater part of the year. England has been the chief destination of the exports during the past year, as the French and Belgian markets have absorbed only small amounts. Toward November the exports to Germany showed a slight increase. It is noted that the exports for the year 1920 amounted to 2,104,545 tons, as compared with 1,513,997 tons during 1919, and 2,253,428 and 2,072,519 tons during 1918 and 1917, respectively. Stocks of ore on deposit in December, 1920, amounted to 650,000 tons, being a decrease from the 780,000 tons in December, 1919. The stocks on hand at the same period of 1918 and 1917 are reported as 300.000 and 690,007, respectively.

EXPORT TAX ON VANADIUM.

By J. H. Roth, Vice Consul, Callao, January 21, 1921.

A law has been passed by the Peruvian Congress and signed by the President on January 19, 1921, whereby a tax of 45.29 sols per metric ton of 2,204.6 pounds will be levied upon all vanadium exported from Peru. This tax will be in force until December 31, 1921. [Sol = $0.468, normal value.]

NEW PHOSPHORUS MINE PURCHASED BY GOVERNMENT STEEL WORKS.

It is reported, states the Far Eastern Review, that a large phosphorus mine, located on Taisho Islands in Okinawa Prefecture estimated to contain 15,000,000 tons of rock containing 28 per cent of phosphorus and recently discovered by Mitsui engineers, is to be purchased by the Government steel works at Yawata in preference to importing supplies from abroad.

GRAPHITE MINE DISCOVERED IN LAIYANG SHANTUNG.

A deposit of graphite suitable for use in making pencils has been discovered near the northwest village of Laiyang, Shantung, states Millard's Review, by Japanese interests. The Laiyang mining administration is said to be taking up an investigation of the deposits, which are extensive.

IRON MINING IN ALGERIA.

The Ouenza Iron Mining Company has just finished the construction of a railroad connecting its property with the line running from Tebessa to Souk-Ahras at a point about midway between these two stations. The length of the new branch is 24.41 kilometers (about 14¼ miles). Ore may now be transported by railway directly from the mine to Bona, the port of embarkation.

The Rouina Iron Mine Company has just increased its capital from $1,686,750 to $2,895,000 for carrying out an important program of expansion. The new work is to include installation of a hydro-electric plant at the mine and one for the town of Philippeville, improvement of loading facilities at Philippeville, and building of workers' houses. The company hopes, by these means, to increase its output above the present 7,000 metric tons per month and to lower cost of production. Labor is easily obtainable in the region.

MARKET FOR AMERICAN COKE DUST IN CZECHO-SLOVAKIA.

Trade Commissioner Geringer of Prague, states that a large manufacturer of Portland cement who uses coke dust in the manufacture is desirous of receiving quotations on American coke dust in shipload quantities. It is necessary that the dust come from the best quality of coke. Further information might be obtained from the European Division, Bureau of Foreign and Domestic Commerce.

GERMAN FIRM OBTAINS CONTRACT TO SUPPLY ARGENTINE RAILROAD WITH CAR WHEELS.

A cablegram received from Commercial Attache Feely, Buenos Aires, dated March 1, 1921, states that the Krupp interests in Germany have obtained the contract for the 10,000 car wheels desired by an Argentine railway.

PEAT PROVES SATISFACTORY FUEL ON SWEDISH RAILWAYS.

Tests extending over several months have passed the experimental stage and conclusively demonstrated that peat, reduced to powder or prepared in the form of briquets, makes an excellent substitute for coal as fuel for locomotives. The Railway Board of Sweden, satisfied with the results of these long-continued tests on the State railroads, has recently taken over the specially constructed plant at "Haesthagen" bog, near Vislanda, with a capacity of 30000 tons per annum and which cost 975,000 crowns ($261,300 at normal rate of exchange. An entirely new method of treating peat on a large scale has been adopted. All the machinery in use, invented and constructed by the engineer in charge, Mr. Ekelund, appears to be so well adapted for the purpose that the conversion of peat into a cheap and effective fuel requires only a small working force. The peat is dried in the open air as far as possible. Only the hardest and driest lumps are used for ordinary fuel, the remainder being converted into powder or briquets. The plant was originally intended for the manufacture of peat powder only, but it was found that briquets were as well adapted for fuel, hence both are now being made. The discovery was also made that powdered peat becomes a dangerous explosive when subjected to high temperature.

AUSTRIAN ARMS FACTORY MANUFACTURING AUTOMOBILES.

The works of the Austrian Arms Manufacturing Company (Oesterreichische Waffenfabriksgesellschaft) in the city of Stepyr, Upper Austria, are now manufacturing high-grade six-cylinder passenger automobiles and trucks by a new method. The end of the war found them with an equipment capable of producing 1,000,000 rifles and other small arms per year. Now they are making a few sporting rifles of the "Mannlicher" model, and shotguns. During the war the works employed about 15,000 men; they now have about 6,000. Thus far the company has produced about 400 automobiles; it expects to produce 4,000 in 1921 and 10,000 in 1922, and to increase after that to 20,000 machines per year. It is said that the automobiles are in great demand, and are now sold in England, France, the Netherlands, Germany, Poland, and Rumania.

NEWS OF THE PLANTS

Gilbert T. Sugden and Charles F. Magoffin, both of Buffalo, N. Y., have organized a new company to take over the rolling mills of Westerman & Co., Lockport, N. Y., manufacturers of rolled iron products. The new company will take immediate possession and, it is reported, will make a number of extensions and improvements in the plant at a later date. The present capacity is about 9,000 tons of material per annum, including such specialties as screw iron, squares, hexagons, rounds, etc.

The Manitoba Rolling Mills, Selkirk, near Winnipeg, Man., has commenced production at its new local blast furnace, said to be the first open hearth plant in this province. The plant comprises a 15-ton furnace, three 15-ton ladles, molds and other equipment. The plant is electrically operated, power being received from the hydroelectric generating plant at Winnipeg. The new plant represents an investment of close to $1,000,000.

The Chester Iron & Foundry Co., Vulcan avenue, St. Louis, Mo., has awarded a building contract to John Dougherty, St. Louis, for the erection of a one-story addition to its plant, 50x100 feet, to cost about $30,000. E. A. Linnis is secretary of the company.

The Inland Steel Company, Chicago, Ill., with mills at Indiana Harbor and Chicago Heights, has completed the erection of the building to be used for its 28-inch mill. The structure consists of an extension to a former building, 90x560 feet, and will be fully equipped for all features of operation. The company has recently increased the plant capacity by changes and improvements. The sheared mill has been changed from a 90-inch to 100-inch plant, and one stand of additional rails has been installed. The work will be divided between roughing and finishing. A new powdered coal plant has been completed and will be placed in service at an early date. The company has abandoned a rolling mill project which it contemplated some months ago.

The American Steel & Wire Co., Grove street, Worcester, Mass., has taken bids for the superstructure of its proposed new plant addition, foundation work for which is now in progress. The structure will be three-story, 120x145 feet, and is estimated to cost about $150,000 with machinery. It will be used for increased production in certain departments.

The Kokomo Steel & Wire Co., Kokomo, Ind., is completing plans for the rebuilding of the portion of its steel plant, recently destroyed by fire. The Indiana Bridge Company, Muncie, Ind., has received the contract for the steel work in connection with the rebuilding. The new structure with machinery is estimated to cost about $300,000.

The Atlas Steel Wheel Company, Rockefeller Building, Cleveland, Ohio, has plans under way for the erection of an addition to its wheel works on Lincoln road for increased capacity. The structure will be one-story, brick and steel, and is estimated to cost about $100,000 including machinery. It is proposed to commence construction at an early date. H. F. Arndt is president.

The Bethlehem Steel Company, Bethlehem, Pa., has work under way on a number of improvements at its plant at Sparrows Point, Md. The extensions will include a four-hole soaking pit furnace for the 40-inch blooming mill, with an extension about 200 feet long to the billet and sheet bar storage runway at the blooming mill section. An extension is being constructed to the ore unloaders and other improvements made in this department to facilitate operations. Coal crushers will be installed for the gas producers at the No. 2 open hearth plant at the 40-inch blooming mill. A considerable portion of this work is expected to be completed at an early date, and will be placed in service as soon as operations require. A number of smaller improvements are also under way at the mills to increase the general efficiency of the works.

E. L. Magill, 60 Devore street, Brooklyn, N. Y., manufacturer of steel products, is arranging for the erection of a new one-story plant on Atlantic avenue, to cost about $50,000.

The Batavia Car Works, Inc., Batavia, N. Y., manufacturer of steel and iron railroad equipment, has awarded a building contract to John Lennon & Co., Batavia, for the erection of its proposed new plant on a local site. The works will cost about $350,000, including machinery. John Baskat is president.

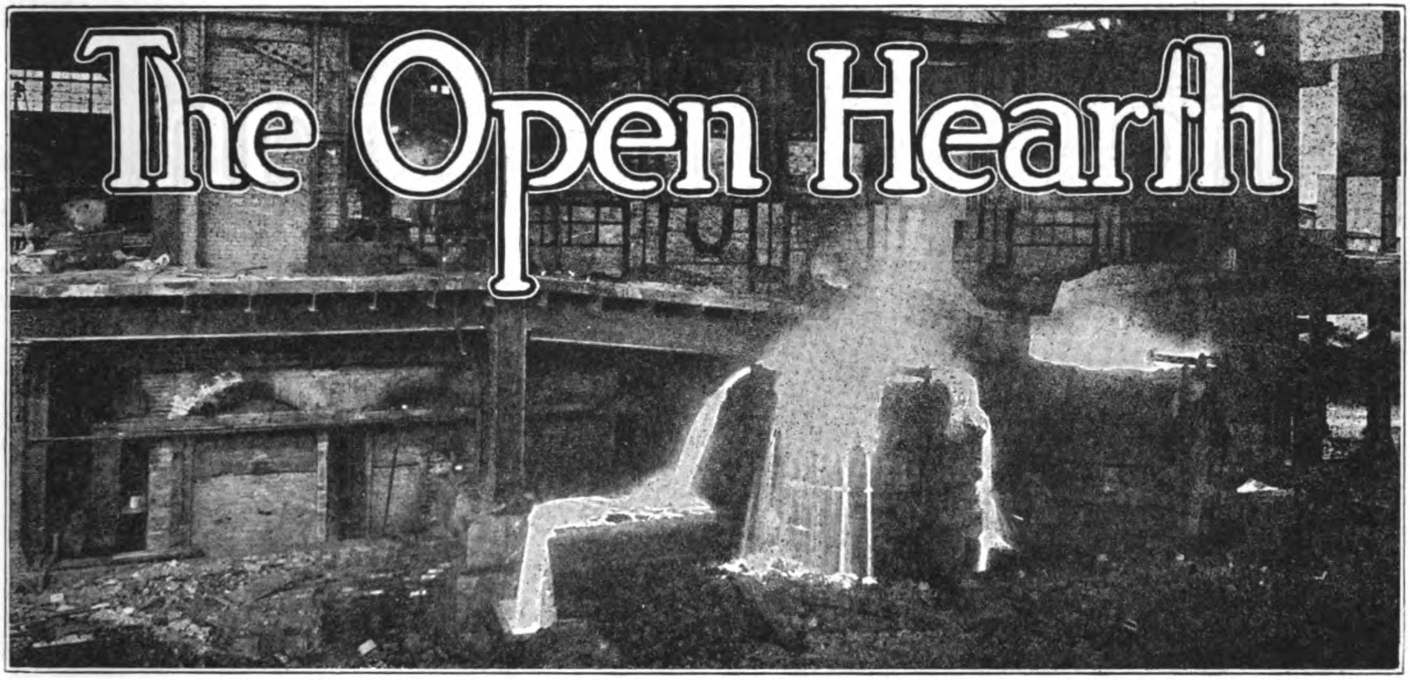
The Electric Steel & Forge Co., Grant avenue, Cleveland, O., has plans under way for the erection of a new steel rolling mill addition at its works. The structure will be one-story, and is estimated to cost in excess of $300,000 including machinery. J. H. Harron & Co., 1360 West Third street, Cleveland, are architects and engineers for the project.

The Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., is making substantial progress in the erection of a new fabricating plant at Fairfield, Ala., to be operated in conjunction with its steel plant at this point. The new works will be used for steel shape production for ship and car material, and is estimated to cost in excess of $1,000,000. The company is also making additions to the finishing department at its bar mills, and similar extensions will be made to the structural and plate mills. At its Ensley, Ala., works, the company has been making a number of minor improvements, including a dry gas cleaner for one of the blast furnaces at this point.

The William H. Beers Company, Park Row Building, New York, iron and steel construction, is developing plans for standardized building construction of all-steel type. The company's system will allow for the erection of buildings of various shapes and sizes under one basic system, bringing the greatest possible economy and efficiency in manufacture and erection. At a later date it is proposed to establish a steel plant for the production of the material, as well as for other iron and steel specialties of rolled section and built-up steel type. The company is headed by William W. Beers and S. F. Tapman.

The Sterling Steel Foundry Company, Eighth street, Braddock, Pa., has preliminary plans under way for the rebuilding of the portion of its works recently destroyed by fire; loss estimated at $75,000.

The Open Hearth



Theodore S. See has resigned his position as Assistant General Superintendent of the Jones & Laughlin Steel Co., Pittsburgh, Pa., and has organized an industrial engineering company with offices in the Oliver Building. Mr. See has been with the Jones & Laughlin Steel Co. for 12 years, having joined the company as production engineer at their Keystone Works. Later he became superintendent of the structural plant. He was rewarded for his successful management of the structural department by being made assistant general superintendent of the entire Pittsburgh plant. Here as head of the efficiency department he also applied his original and productive ideas to the open hearth and steel works. He has been unusually successful in installing practical production systems which have resulted in phenomenal increases in tonnage with corresponding reductions in costs. Mr. See was with the Riter-Conley Company for four years previous to his connection with the Jones & Laughlin Steel Co. As a token of the high esteem in which Mr. See was held, the superintendents and employes presented him, upon his resignation, with a suitably engraved gold watch. Mr. See is a member of the American Society of Mechanical Engineers and the Engineers Society of Western Pennsylvania.

* * *

F. J. Griffiths, vice-president and general manager of the Central Steel Company, Massillon, Ohio, was elected a member of the board of directors and vice-president of the Massillon Rolling Mill Company, Massillon, at the recent annual meeting.

* * *

Edgar C. Felton, a former president of the Pennsylvania Steel Company, Steelton, Pa., was elected a director of the Pensylvania Railroad, succeeding A. W. Mellon, who resigned owing to his appointment as Secretary of the Treasury.

* * *

H. W. Torney, New York, was elected president of the Sharon Pressed Steel Company, Sharon, Pa., at a recent meeting of the directors, and succeeds Mr. J. D. Corcoran, who served as president for the past year. Mr. Torney is head of Torney & Co. and association with J. S. Pardee & Co., bankers of 66 Broad street, New York. A. W. Morris was elected vice-president in charge of sales, while A. F. Swan, who was formerly chief engineer of the Crucible Steel Company of America, at its Harrison, N. J., plant, will be in charge of operations. Mr. Torney has assumed his duties with the company.

* * *

At the recent annual meeting of the Wellman-Seaver-Morgan Company, Cleveland, three new directors were added to the board, these being Arthur G. McKee & Co., George W. Burrell, vice-president and works manager of the company, and A. G. Tame, vice-president of the Cleveland Trust Company.

* * *

Roger M. Freeman has gone into business for himself as construction engineer, with headquarters at 8 West Fortieth street, New York. Mr. Freeman had charge of the design and construction of the armor plate and gun forging plant for the navy department at South Charleston, W. Va. As supervising engineer for the navy, Mr. Freeman was in charge of the construction and design of the Erie Forge & Steel Co., Erie, Pa.; the forging plant of the Pollak Steel Company, Cincinnati; and the heat-treatment plant of the Allis-Chalmers Company, Milwaukee.

* * *

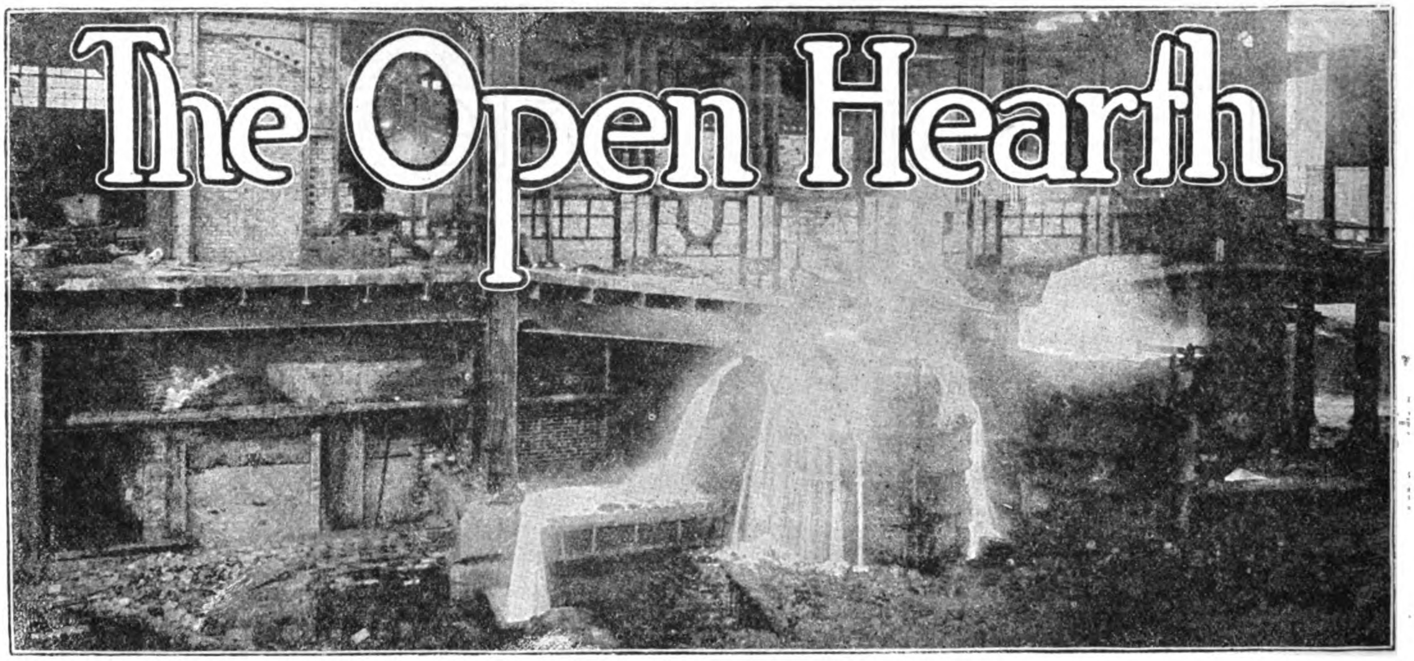
R. J. Emerich, secretary and treasurer of the W. W. Sly Manufacturing Company, Cleveland, has been elected president and general manager succeeding the late W. C. Sly. George P. Steel as treasurer and S. C. Vessy as secretary succeed Mr. Emerich. George J. Fanner continues as vice-president and, with the other officers and Paul Ryan, constitutes the board of directors. L. Bottomley succeeds the late G. K. Fanner as superintendent. Mr. Sly and Mr. Fanner were killed defending the company's payroll from bandits, December 31, 1920.

* * *

R. M. Marshall has been appointed general manager, Leon A. Ehrman superintendent of blast furnaces and H. Frank Shaffer, general master mechanic of the American Manganese Manufacturing Company, Dunbar, Pa. Mr. Marshall formerly was superintendent of blast furnaces, Mr. Ehrman formerly assistant superintendent of furnaces and Mr. Shaffer formerly furnace master mechanic, all of the Midvale Steel & Ordnance Co., Coatesville, Pa.

* * *

Andrew W. Mellon, who has been appointed secretary



The Open Hearth

of the treasury by President Warren G. Harding, in addition to being head of the Mellon National Bank, Pittsburgh, is prominently identified with a large number of industrial corporations connected directly or indirectly with the iron and steel industry. He has resigned as director in the following companies: Aluminum Company of America, Aluminum Ore Company, American Locomotive Company, Baltimore Car & Foundry Co., Butler Bolt & Rivet Co., Butler Car Wheel Company, Carborundum Company, Crucible Steel Company of America, Forged Steel Wheel Company, Koppers Company, McClintic-Marshall Company, Middletown Car Company, McClintic-Marshall Construction Company, Minnesota By-Product Coke Company, Pittsburgh Coal Company, Pittsburgh Model Engine Company, Pressed Metal Radiator Company, Riter-Conley Company, Riter-Conley Manufacturing Company, Seaboard By-Product Coke Company, Standard Motor Truck Company, Standard Steel Car Company, Steel Car Forge Company, Union Shipbuilding Company, United States Aluminum Company, and the Verona Steel Castings Company.

V V

Chairman E. H. Gary of the United States Steel Corporation, is to sail for Europe in the very near future, presumably in connection with the proposed organization of an international association of steel-makers. At a recent meeting of the directors of the American Iron and Steel Institute, Judge Gary was empowered to direct his efforts toward the carrying out of this plan.

V V

J. M. Flood has been promoted to assistant master mechanic at the Youngstown Sheet & Tube Co.'s Youngstown Plant.

V V

N. Price Whitaker, secretary Whitaker-Glessner Company, a subsidiary of the Wheeling Steel Corporation, has been mentioned as a possible Assistant Secretary of War.

V V

T. W. Oberhauser, who was appointed Pittsburgh district sales manager of the Wheeling Steel Products Company recently, sales subsidiary of the Wheeling Steel Corporation, for the past three years, has served in a similar capacity for the Wheeling Steel & Iron Co. Before joining the sales organization of the latter Mr. Oberhauser had been with the Crane Company, Chicago, for about 10 years.

V V

E. J. Wood, formerly in the works management department of the Westinghouse Electric & Mfg. Co., for six years before the war, is now manager of the factory control department of the Columbian Enameling & Stamping Co. at Terre Haute, Ind. Before going to the enameling plant, Mr. Wood was doing industrial engineering and accounting work at the Firestone tire and rubber plant in Akron, Ohio.

V V

At the annual meeting of the stockholders of the Jackson Iron & Steel Co., Jackson, Ohio, all the old board of directors were re-elected. The board re-elected the following officers: President, Simon Labold; vice-president, D. D. Davis; secretary-treasurer, J. F. Morgan; general manager, Noah G. Spangler; superintendent, O. O. Laudig.

V V

Richard Trimble, secretary and treasurer of the United States Steel Corporation, who has been seriously ill for the last few days, is improving materially.

V V

H. W. Torney, head of Torney & Co., New York, has been elected president of the Sharon Pressed Steel Company, Sharon, Pa., succeeding J. D. Cochran.

V V

Charles Taggart, for 20 years foreman of the finishing department of the National Malleable Castings Company's plant, Sharon, Pa., has resigned to become associated with the Dominion Foundries & Steel Co., Hamilton, Ont.

V V

Louis Muench has retired from active service as manager of the Republic plant of the Vulcan Detinning Company, Neville Island, Pa., retaining his interest as stockholder and director. R. D. O'Neil, who for a number of years has been superintendent, succeeds Mr. Muench as manager.

V V

James Arnold, recently appointed director and general manager of the Canadian Foundries & Forgings, Ltd., was formerly assistant manager at the plant at Brockville, Ont. He was at one time a resident of Montreal in connection with the hardware trade and during the war served with the imperial munitions board. He is also vice-president of the Mann Axe Company, Ltd., St. Stephen, N. B.

WITH THE EQUIPMENT MANUFACTURERS

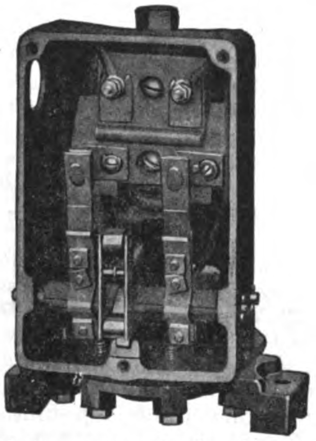
PRESSURE-OPERATED SWITCH OF UNUSUALLY COMPACT DESIGN.

A pressure regulator of the diaphragm type, which has recently been developed by The Cutler-Hammer Manufacturing Co. of Milwaukee, Wisconsin, is much more compact and simpler in design than the other C-H diaphragm type regulators. This new device which is known as Bulletin 10004, is arranged for easy mounting, and its three overall dimensions are 6, 6½ and 8 inches. It is used with motor-driven pumps or compressors controlled by a main line magnet switch or some other suitable automatic starting device. It has two poles, which enables it to be used also for connecting small A. C. and D. C. motors directly to the line.

New C-H pressure-operated switch for automatically controlling motor-driven pumps and compressors.

The air, water, or other fluid under pressure is conducted into a chamber in the base of the regulator, and the pressure acts against a rubber diaphragm and compresses a spiral spring, the normal compression of which can be changed by means of an adjusting nut to obtain various values of opening pressures up to 60 pounds per square inch. When the switch is closed and the pump or compressor operating, the pressure builds up, and when the adjusting spring has been compressed to a certain point, the switch snaps open and stops the motor. When the pressure has fallen to a predetermined point, the switch closes with a quick action, and the pump or compressor again operates to build up the pressure system.

This snappy make-and-break action of the switch is accomplished by an arm carrying a roller which is held in tension against a cam mounted on the operating shaft of the switch. The movement of the adjusting spring is transmitted to the roller which moves along the surface of the cam. When the opening or closing pressure is reached, the roller passes a peak on the cam, and gives the latter a quick turn, thereby opening or closing the switch. A good contact pressure is maintained up to the instant the switch is opened. The difference between opening and closing pressures is about 20 pounds.



Cover removed, showing interior construction of switch.

The entire mechanism of the regulator is enclosed in a cast iron case arranged for the entrance of conduit. Terminals and fingers are exposed by taking off the cover of the case, which necessitates only the removal of three screws.

The regulators are at present made for 60 pounds maximum service, and it is expected that they will shortly be provided for use on systems up to 200 pounds pressure with few slight modifications in design.

RIVET CUTTING RECORD.

What is believed to be the record to date for cutting rivets in the dismembering of steel freight cars was recently established by an operator who cut out 1,038 rivets in 2 hours and 46 minutes. Of this number 683 were ⅝-inch rivets, 288 were ¾-inch rivets, and 127 were ⅞-inch rivets.

The cutting was done on a standard Erie car under general yard conditions, the operator taking the rivets as they came, working inside, outside and under the car. The car was one that had been retired from active service and that was in the car shop for repair, the rivets and plates being covered with heavy scale and rust, thereby rendering the cutting extremely difficult.

It is said that the record applies not only to the number of rivets cut in the time required but also to the low consumption of gases used, the job taking only 384 cubic feet of oxygen and 83 cubic feet of acetylene. The operator used an Oxweld cutting blowpipe with a rivet cutting nozzle.

SLAG POCKETS FOR OPEN-HEARTH.

The removal of slag from chambers after a run, or in case the furnace has broken out causing both slag and metal deposited in slag pocket to be broken up and carried to dump or skull cracker, whichever the practice of that particular plant demands, has always been a tedious and trying task for both men and superintendent.

With the design of slag chambers of ample width, due to the gas and air passageways to furnace ports from checker chambers and height below discharge ports of checker chambers at furnace uptakes, the volume of slag that can, under normal conditions of furnace operation, be carried until the period of general repairs are to be made, is sufficient so that no occasion would require the shutting down of the furnace unless a break or unforseen bath condition would force down the uptake flues and deposit into these chambers excess slag and metal that ordinarily is discharged at the trough from the furnace at the end of a heat.

The use of the older methods of slag removal which means, to tear away the entire front wall and with the aid of picks, wedges, bars and not to mention the confined quarter for men at all times, and hot work during the summer months—has caused at times a demand from laborers of an increase in pay before they would work under these conditions; or with the aid of slag guns using fewer men and getting the slag out quicker, which still requires days under the best of working conditions, has, within the past few years, brought out the feasibility of making a water cooled pocket. which would set the slag as quick as its heat would penetrate the wall and into the jacket or pipes of cooling water or with the aid of chill plates outside a thin wall cause the slag to set quickly. The contraction of the slag was depended upon to free itself from the side walls and therefore in case of removal be easier to dig out.

The Whalen Removable Air-Cooled Slag Pocket is an item of but small expense to insert as old beams, rails, rods and plates can be used and it does not require special piping, buckstays, cooling plate, etc.

TRADE NOTES

Dwight P. Robinson & Co., Inc., a large firm of engineers and constructors of New York, has recently opened branch offices in Montreal in the Dominion Express building. Alexander C. Barker, vice-president, is in charge of the office. The company is a consolidation of Westinghouse, Church Kerr & Co., Inc., and Dwight P. Robinson & Co., Inc., and has done extensive construction and engineering work in Canada for the Canadian Pacific Railway, Canadian Salt Company, Canadian Crocker-Wheeler Company, Dominion Government, Aetna Explosives Company, Grand Trunk Railway and others.

The appointment of Mr. J. B. Crane to the sales and engineering department of the George T. Ladd Company, manufacturers of the Ladd Water Tube Boiler, has just been announced. Mr. Crane has had over 15 years' experience in the construction and operation of power houses and has a wide acquaintance among the public utilities, engineers and mining men in various parts of the country.

The Pittsburgh office of the Independent Pneumatic Tool Company, was moved on February 26, from the old address of 1208 Farmers Bank building, to 718 Bessemer building, corner of Fort and Duquesne Way, Pittsburgh, Pa.

The Midvale Steel & Ordnance Co. have placed an order with Arthur G. McKee & Co., Cleveland, covering the furnishing of a McKee revolving distributor for their No. 1 furnace at Coatesville, Pa. This makes a total of 124 McKee revolving distributors in operation or under construction.

The Blaw-Knox Company of Blawnox, Pittsburgh, Pa., with branch offices in the largest cities from coast to coast, is now entrenching itself in the South. Having but recently established a district sales office in Birmingham, Ala., the company on April 1 opened up a new sales territory in the Southwest, with headquarters in Kansas City, Mo. In addition, the Blaw-Knox Company has sales offices in New York, Chicago, Detroit, Boston, Baltimore, San Francisco and Sheffield, England.

Grindle Fuel Equipment Company hereafter will be the name of the Powdered Coal Company, formerly known as Combustion Economy Corporation. The capital stock has been increased to $1,000,000 in Illinois, and the company is having plans prepared for building a manufacturing and demonstrating plant, to consist of a foundry, machine and sheet metal shop, office and engineering department, a complete powdered coal preparation plant, and other departments necessary for the manufacture of powdered coal equipment. The complete plant will utilize powdered coal for fuel, and conveying system and firing equipment of the company's manufacture will be installed.

The Electric Furnace Construction Company, 908 Chestnut street, Philadelphia, announce that they have closed a contract for a large electric heat-treating furnace with the Yale & Towne Mfg. Co., Stamford, Conn.

Messrs. H. A. Greaves and H. Etchells have recently been granted a new patent on a 3-electrode electric melting furnace. These patents are controlled by the Electric Furnace Construction Company, Philadelphia.

The steady increase in business of the Conveyors Corporation of America, formerly American Steam Conveyor Corporaiton, Chicago, has necessitated doubling the number employed in their South Bend, Indiana plant. The Conveyors Corporation manufacture the American Trolley Carrier and the American Steam Ash Conveyor.

TRADE PUBLICATIONS

The Griscom-Russell Company have issued Bulletin No. 315, describing the G. R. Multiscreen Filter, a redesign of the famous Reilly Feed Water Filter and Grease Extractor.

The American Roller Bearing Company have issued Bulletin No. 1005 which fully describes the Type "C" Roller Bearings made by their Company. Included are photographs of machinery showing where these roller bearings have been installed. It also mentions the engineering coöperation which the company is always ready to furnish.

The Bacharach Industrial Instrument Company of Pittsburgh, Pa., have just issued a folder showing their new quarters, a handsome brick building of 18,000 square feet floor space at Homewood Station, Pittsburgh. The additional space which they have acquired by the purchase of this building has increased considerably their facilities in giving prompt and efficient service to their customers. The products handled by the company are given on page two of the folder and consist mainly of gas meters, air meters, pressure recorders, draft recorders, pitot tubes and orifices, CO_2 indicators, manometers and engine indicators.

A new departure in combustion control devices is described in an illustrated bulletin recently issued by the Mono Corporation of America, 25 West Broadway, New York City. The Duplex Mono, as it is called, is unique in that it automatically analyzes and records the combined percentages of three combustible gases (CO, CH_4, and H_2) during all such times as any or all of these appear in the flue, while it also produces a continuous accurate record of the percentage of CO_2.

George J. Hagan Company of Pittsburgh, Pa., have recently issued a booklet covering the Hagan hand-stoked gas producers. These producers are built for economical and efficient production of bituminous producer gas and there is no question but what they will live up to the reputation of the other Hagan products. The booklet explains the characteristics of the gas produced, description of the producer, and general information regarding the various fuels which can be used in the producer. It also contains some line drawings of the producer.

Anderson Visible Pump & Tank Co., Savannah, Ga., is circulating a 6-page illustrated folder in which quick delivery, self-measuring gasoline pumps, as well as tanks, oil and gasoline storage systems, etc., are described and illustrated.

The Hill Clutch Company, Cleveland, is circulating a 4-page illustrated bulletin in which transmission machinery in a modern oil refinery is described and illustrated. The information given is interesting and valuable.

The Seybold Machine Company, Dayton, O., is circulating an illustrated booklet of 16 pages, in which various parts of the company's plant are described and illustrated. The booklet is entitled "A Trip through the Plant of the Seybold Machine Company." This plant is said to be one of the largest in the world devoted exclusively to the manufacture of machinery.

COMING MEETINGS.

April 21-23—American Electrochemical society. Spring meeting at the Hotel Chalfonte, Atlantic City, N. J. Joseph W. Richards, Lehigh university, Lehigh, Pa., is secretary.

May 5-6—British Iron & Steel Institute. Spring meeting at the Institution of Civil Engineers, Great George street, London, S. W. 1. The secretary is Geo. C. Lloyd, 28 Victoria street, London, S. W. 1.

May 9-10-11—American Association of Engineers. Annual convention to be held in Buffalo. National association headquarters, 63 East Adams street, Chicago.

May 19-20 — National Machine Tool Builders' Association will hold its spring convention at Hotel Traymore, Atlantic City, N. J.

May 23-26 — American Society of Mechanical Engineers. Spring meeting, Congress hotel, Chicago. Calvin W. Rice, 29 W. Thirty-ninth street, New York, is secretary.

June 22-26—American Drop Forge Association. Annual meeting will be held in Chicago. E. B. Horne, 1516 Helen avenue, Detroit, is secretary.

September 19-24 — American Society for Steel Treating. Annual meeting will be held in the Manufacturers' Building, State Fair Grounds, Indianapolis. W. H. Eiseman, 4600 Prospect avenue, Cleveland, O., is secretary.

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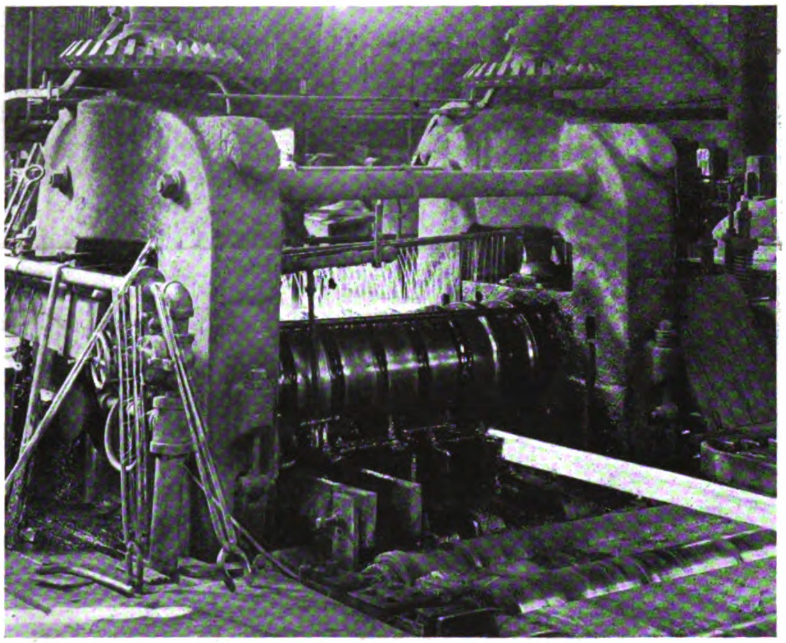

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